A Cumulative Assessment of the Environmental Impacts Caused by Kentucky Electric Generating Units

Prepared by:
The Kentucky Natural Resources and Environmental Protection Cabinet

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Commonwealth of Kentucky
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Acknowledgement

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Executive Summary

Governor Patton, on June 19, 2001, declared a six-month moratorium prohibiting the Cabinet for Natural Resources and Environmental Protection from accepting additional applications for new electric generating facilities. This was established in order to evaluate the cumulative impact of an increase in Kentucky's electric generating capacity and to insure that appropriate decisions are made. During this time the Cabinet for Natural Resources and Environmental Protection and the Public Service Commission were instructed to study the impact of power generation in their respective areas of responsibility. This report was prepared in response to this mandate.

Currently there are 34 power plants operating in Kentucky that collectively produce approximately 18,000 megawatts of power. There are 22 coal burning facilities, seven hydroelectric plants, three natural gas plants, and two plants that burn fuel oil. Five of the coal burning plants also burn either natural gas or fuel oil. Of the 39,258,000 tons of coal used for electricity generation in Kentucky in 1999, 24,558,000 tons, or 63 percent was mined in Kentucky.

Since October 1999, the Cabinet has received applications for the construction of 22 new or expanded power plants. Twelve of the new plants will operate only on a peaking basis - during times of high energy demand - and will not operate seven days a week, 24 hours per day like many of Kentucky's existing power plants. In addition, a majority of the new plants will burn natural gas as opposed to coal. Fourteen proposed plants will burn natural gas, four will burn waste coal, three will burn traditional coal, and one plant will burn a combination of gasified coal and residential garbage. If all of the proposed plants are constructed as currently designed, collectively they will generate approximately 11,000 megawatts of power. Of this cumulative total, peaking plants will generate approximately 50 percent of this energy. This is in sharp contrast to ten percent, which is the current amount of energy that is being generated on a peaking basis. If all power plants were built, the total amount of power generated on a peaking basis, considering both the existing and proposed plants, would be over 7000 megawatts. This would account for approximately 25% of the total power generated in Kentucky.

The Cabinet has evaluated the cumulative impact of Kentucky's existing and proposed power plants on Kentucky's environment. In order to make conclusions about the environmental capacity of Kentucky to accommodate additional power generation, an evaluation of the environmental impacts of existing power plants was necessary. This evaluation process allowed establishment of a baseline for comparison of predicted impacts and also provided data for predictive estimations of impacts from plants that are not yet built. All media were considered: air, water, and land. Human health and biotic impacts were evaluated where possible. The Cabinet used existing permit data, reported releases to federal data systems, and permit applications to prepare this document. Where quantitative information was available for this report, an evaluation was conducted. If specific data were not available, the Cabinet discussed the issues in a more qualitative manner. For the purposes of this report, only direct impacts to the environment from actual power plants were evaluated. This report is limited in scope. The time constraints for this project prevented a comprehensive analysis of all environmental issues. The Cabinet did not consider any costs or benefits of power generation.

Cabinet analysis indicates that coal plants generate and release the most waste. Reported data on the existing coal plants shows that they contribute 60 percent of the toxic air pollutants released in Kentucky, 44 percent of the nitrous oxide (NO_x) emissions, and 84 percent of the total sulfur dioxide released to the air. They are also significant sources of carbon monoxide and carbon dioxide. In addition, according to the release information, coal-fired power plants discharge over 40 percent of the total amount of toxic chemicals released into Kentucky's waters. Relative to coal-burning plants, natural gas plants are not a significant source of toxic air pollutants or water pollutants, and do not generate ash as a byproduct of the combustion process.

Two different air modeling exercises were performed using existing data and projected emissions for the proposed plants. Indications from the air toxics modeling and risk assessment of these results, show that some of the plants release air toxics at levels that could be harmful to human health. Additional modeling indicates that the state should remain below the 1-hour ozone standard even if all of the proposed plants are constructed. However, it is anticipated that, even with the expected NO_x reductions at existing power plants, some counties in Kentucky may exceed the 8-hour standard, whether or not the new plants are constructed. If areas of Kentucky are not able to meet the 8-hour ozone standard, additional control measures may be required of all sources that contribute to ozone formation.

Using Cabinet permitting data to evaluate environmental impacts of existing plants, the Cabinet found that coal-fired plants withdraw more than three billion gallons of water from Kentucky's streams each day. Based on an evaluation of the percentage of the low flow of the streams that are used as source water compared to the amount of water withdrawn, some of these withdrawals are at rates that may not be protective of aquatic systems or additional downstream water supply needs during periods of low stream flow. It is anticipated that the proposed coal burning plants will also withdraw a significant amount of water. However, the Cabinet will have more ability to ensure protection of Kentucky's water resources because it is anticipated that some of the proposed power plants will not be regulated by the Public Service Commission and will not be automatically exempt from water withdrawal requirements. Natural gas-burning plants do not require large amounts of water and will not pose similar potential impacts.

An examination of wastewater discharges from existing power plants indicates there are no significant human health concerns after mixing with the receiving stream. Proposed plants are expected to have similar discharges. An analysis of proposed locations for the new plants show that one of the proposed natural gas, peaking power plants is located within 5 miles of a water treatment plant. Another proposed power plant is located within a source water protection zone of a drinking water plant and could affect the quality of the drinking water supply. These conditions may not preclude the proposed plants from obtaining a wastewater discharge permit. If necessary, however, their proximity to a drinking water plant may restrict the permitted discharges, in order to protect the drinking water source.

An evaluation of the ash landfills at coal-fired plants indicates that ash landfills can contribute to groundwater contamination. Ash produced by the new coal burners will be one and one half times greater than ash produced by the existing coal plants, because waste coal will be burned. Currently nine million tons of ash are generated each year. This is expected to increase to 15 million tons. This will require the additional development of ash landfills and slurry ponds, which may result in an impact on groundwater. Finally, both the existing and proposed power plants may contribute to acid and metals deposition that, even at low concentrations, will over time contribute to soil toxicity and bioaccumulation of heavy metals, such as mercury. See Appendix I of this document for the text of Kentucky’s statewide fish consumption advisory.

This analysis is based on conservative assumptions. For example, the Cabinet assumed that all proposed power plants would be built and operate at maximum capacity, atmospheric conditions were used in the modeling that were favorable for ozone formation, surface water and groundwater were evaluated as if an individual would use that water as a drinking water source, and the assumption was made that all ash would be disposed rather than reused.

The Cabinet has made specific recommendations that will help ensure protection of public health and the environment from existing and proposed power generation. Implementation of these recommendations will reduce impacts from the existing power plants and allow the construction of the proposed power plants without posing an unacceptable impact on Kentucky's citizens and the environment. Any additional plants proposed in excess of those that have already applied to the Cabinet for a permit would need to be carefully evaluated to ensure that they could be built and operated in a manner that is protective as well.

Conclusions

Waste Generation

In 1999, Kentucky facilities released nearly 106 million pounds of toxic substances. The Toxics Release Inventory (TRI) indicates that based on the total volume of toxic waste released on-site in 1999, nine of the top ten facilities in Kentucky were electric generating units. In fact, as a whole, power plants released more toxic substances on-site than all other TRI reporting facilities combined.

About half of the on-site toxic releases occurring at existing coal burning power plants are released into the air. In 1999, over 44 million pounds of air toxics were released by power plants. This accounts for nearly 60 percent of all air toxic releases reported in the Commonwealth. The total amount of toxics released into the air by all of Kentucky's industries was approximately 75 million pounds.

The primary air toxics released from Kentucky coal-fired power plants as reported on the 1999 TRI were hydrochloric and sulfuric acid. These two chemicals accounted for 96 percent of the total air toxics reported by these plants on the 1999 inventory. Coal burning power plants also accounted for 44 percent of the nitrous oxide (NO_x) emissions and 84 percent of the total amount of SO_2 released in Kentucky.

Natural gas plants have lower air emissions and release fewer contaminants to the air than coal burning plants. However, it is expected that the proposed new plants that will burn coal or waste coal as the primary fuel will cause the air toxics release values reported on the TRI to increase.

All power plants, regardless of fuel, are sources of carbon dioxide (CO_2), carbon monoxide (CO), and particulate matter.

According to the 1999 TRI, power plants contribute over 40 percent of the total toxic chemicals released into the water. These releases are two times greater than the next closest industrial group. As with air releases, it is not expected that new natural gas burning plants will contribute a significant increase in the amount of toxics released to water.

Kentucky is ranked as one of the top ten states for the release of mercury originating from power plants. Early data reported to the EPA for 2000 show that 4,946 pounds of mercury were released by power plants. 1,400 pounds of mercury were released to surface impoundments and an additional 3,546 pounds of mercury were released from air stacks, which presumably settles on land or in water.

The existing coal fired plants create approximately nine million tons of ash per year. Information provided to the Cabinet suggests that the proposed plants will produce 15 million tons of ash per year - more than a two-fold increase for a total of 24 million tons per year.

Air Quality Impacts

Air models are used to evaluate and predict impacts of emissions. The Cabinet used modeling to evaluate air quality impacts. Because of time limitations, historic 1995 emissions for Kentucky were used to model the criteria air pollutants from existing plants, because this data was readily available. The potential emissions from the new power plants were added to this data set. This provides a conservative "worst case" scenario for the greatest potential impacts from the new power plant emissions.

Projected emissions from the new power plants are anticipated to add an additional 74 tons per day of NO_x. In 1995, existing power plants emitted 1,155 tons of NO_x per day. NO_x is a key chemical in the formation of ozone.

Most states east of the Mississippi River, including Kentucky, have federal mandates to reduce NO_x emissions, primarily from power plants, by 2004. The total amount of NO_x emissions budgeted to KY is 165,354 tons per year. Power plants will be allocated 36,504 tons of this total budget.

The 1-hour ozone standard is set at 0.12 parts per million (ppm) and is a three-year standard. 1-hour ozone values throughout the state should remain below the 0.120 ppm standard after all the 22 new power plants are in operation.

The 8-hour ozone standard, adopted by U.S. EPA in 1997 is set at 0.08 ppm. Like the 1-hour ozone standard, the 8-hour standard is a three-year standard. However, unlike the 1-hour ozone standard, which looks at the single highest 1-hour value, the 8-hour standard is based on the average highest 8-hour readings for a day. Based on EPA's modeling, new power plants are projected to have an impact on 8-hour values in parts of the state even after expected NO_x reductions from existing power plants. These areas will have the potential to exceed the 8-hour standard. Modeling indicates that this is possible in the Lawrence/Boyd County area and the Daviess/Henderson County area from additional emissions from the Dynegy Riverside facility in Lawrence County and the Grane Creek and Cash Creek facilities in Henderson County. It is anticipated that these exceedances will occur even after the expected NO_x reductions at existing power plants.

In a few instances, increasing NO_x emissions actually decreased ozone formation to a slight degree, in specific small areas.

Kentucky is currently meeting the 24-hour fine particulate standard. Fine particulate matter has two standards; a 24-hour standard set at 65 micrograms per cubic meter (ug/m3), and an annual standard set at 15 ug/m3. Currently there are several areas of the state that have the potential for not meeting the annual standard. Modeling projects that the additional emissions from the new electric generating units will not contribute significant amounts of precursors for fine particulate matter in Kentucky.

Hazardous air pollutants, also known as air toxics, are chemicals that can cause serious health and environmental hazards. The Cabinet identified 13 hazardous air pollutants that warranted specific evaluation. These pollutants were modeled to determine the threats to human health. Based on the dispersion modeling output, there are four chemicals that exceeded their risk-based screening value for human inhalation. All four of these pollutants are carcinogens. The four chemicals that exceeded their screening values were arsenic, beryllium, total chromium and nickel. The modeling indicates these chemicals may occur at a level of concern. Chromium was the chemical found at the highest level of concern. Modeling predicted that the existing Reid/Green/ Henderson complex releases this chemical at greater than 50 times the screening value. There were four chemicals that did not exceed the screening level, but were high enough to warrant additional attention. These chemicals were benzo(a)pyrene, cadmium, formaldehyde and hydrogen chloride. These chemicals may be at safe levels when evaluated individually; however, collectively they may contribute to the total risk from the facility, particularly when several chemicals act on the same human organ system.

Water Quality Impacts

An analysis of water withdrawals at existing plants indicate that coal-fired plants withdraw more than three billion gallons of water from Kentucky's streams each day. Based on evaluation of the percentage of the low flow of the stream that is being withdrawn, some of these current withdrawals are at rates that may not protect aquatic systems or additional downstream water supply needs during periods of low stream flow.

An examination of wastewater discharges from existing power plants indicates that although the actual discharges are not safe for human recreation or human consumption, after the discharge becomes mixed with the receiving stream, there are no significant human health concerns.

When the power plant discharges are evaluated using the new standard for arsenic, the discharges slightly exceed the new Drinking Water Maximum Contaminant Level (MCL) even after the effluent is mixed with the receiving stream. This indicates that additional treatment is necessary prior to public consumption. In addition, the discharges are not safe for recreational contact until after they are mixed with the receiving stream.

It is anticipated that the proposed coal burning plants will withdraw a significant amount of water and will contribute similar wastewater discharges to Kentucky's streams as identified at existing coal-fired plants.

One of the proposed natural gas plants is located within 5 miles of a water treatment plant. Another proposed power plant is located within a source water protection zone of a drinking water plant and could affect the quality of the drinking water supply. These conditions may not preclude the proposed plants from obtaining any necessary wastewater discharge permit however, their proximity to a drinking water plant may restrict the permitted discharges, in order to protect the drinking water source.

An ecological assessment determined that six of the 12 plants that were evaluated had calculated exceedances of Water Quality Standards for the Warm Water Aquatic Habitat use category. The pollutants identified in surface water as a problem included chromium, copper, lead, manganese, nickel selenium, zinc and iron.

The ecological assessment also evaluated the results of toxicity testing required at 19 of the existing power plants. The results of this test show that the majority of power plants seem to be operating in a manner that is protective of aquatic life. However, despite the fact that most of the toxicity tests showed acceptable results, excessive toxicity was reported for four plants.

Ash is typically disposed in either ash landfills or ash ponds. Unlike special waste landfills, there are no requirements for groundwater monitoring around ash ponds. It is possible for these landfills and ponds to seep leachate into groundwater and eventually surface water. This can effect the health of aquatic and terrestrial systems. The Cabinet does not have adequate data to determine the extent that ash ponds have contaminated groundwater.

An analysis of one ash landfill showed that arsenic and barium were above risk-based levels in the groundwater downgradient from the landfill. This indicates that there may be a risk to humans from arsenic if they use that water for drinking without adequate treatment.

Land Quality Impacts

There are currently 16 ash landfills permitted totaling 6,062 acres of land for disposal of ash from existing power plants. Approximately one acre of landfill space is required to dispose 100,000 tons of ash. At the current rate (assuming fill depth of 60 ft, 50 acres per year filled) 1,000 acres of permitted area will accommodate the existing volume of ash being landfilled for the next 20 years, the average life expectancy of a landfill. In addition, all ash from coal mined in Kentucky and burned in Florida is returned to Kentucky for ultimate disposal. At least one additional facility takes ash from out of state power plants.

It is anticipated that ash produced by the new coal burners will be one and one half times greater than ash produced by the existing coal plants, because waste coal will be burned at four of the proposed locations. The four proposed waste coal burning facilities will significantly increase the amount of landfill disposed ash. These four plants will landfill approximately nine million tons of ash per year, compared to the five million tons per year currently landfilled by the existing power plants. Approximately 90 acres of additional landfill space will be used each year to accommodate this waste.

Kentucky regulations allow structural fill and other beneficial reuses of ash with very little oversight and few limitations. The generator of the ash does not need a written permit for beneficial reuses. The generator is only required to submit an annual report with the amount of ash and the name and address of the recipient, and specific reuse only if known.

Existing power plants may contribute to acid and metals deposition that, even at low concentrations, may over time contribute to soil toxicity and bioaccumulation of heavy metals, such as mercury, in wildlife populations. See Appendix I of this document for the text of Kentucky's statewide fish consumption advisory.

Secondary Impacts

There are also indirect impacts to the environment associated with electric power generation. Time constraints permitted the Cabinet to only analyze the impacts from power plant operation. Additional evaluation needs to be conducted to determine the cumulative impacts associated with these secondary impacts.

Currently, sixty percent of the coal burned by Kentucky coal burning power plants is mined in Kentucky. Historically, coal mining has had significant impacts on the environment.

Other power plants burn oil and natural gas extracted from wells in Kentucky. If not managed properly, these wells can have adverse impacts on Kentucky's resources.

The fuel processing and refinement process can produce pollutants that must be managed to prevent environmental degradation.

Barges, rail systems, and gas pipelines are used to transport power plant fuel. Each of these can cause impacts to the quality of Kentucky's environment. There are also potential indirect impacts associated with the construction and operation of a power plant.

Facility construction itself may cause the permanent loss of wetlands or other unique habitats.

Once operating, plant noise and an increase in traffic may disturb local residents.

Recommendations

The Cabinet's analysis indicates that there are environmental impacts associated with the operation of existing power plants and potential impacts associated with the proposed power plants. However, these impacts can be mitigated to allow conformance with existing requirements and be protective of projected risks.

Existing Plants

Existing plants are generally in compliance with existing environmental requirements. However, there are some problems that need to be addressed. These concerns include:

- The potential for non-attainment designation of the 8-hour ozone standard;
- Toxic air releases;
- Excessive water withdrawal;
- The potential for surface water contamination;
- Groundwater contamination at ash ponds and landfills;
- Metals deposition that causes potential bioaccumulation and soil toxicity;
- Disposal of ash; and
- Inappropriate use of ash as a fill material.

Proposed Plants

Cabinet analysis indicates that the proposed plants will not create new environmental problems and will not extensively exacerbate existing conditions. This conclusion is supported by the fact that the proposed plants will be required to implement new technologies that reduce their emissions, which will set the standard for future construction at new and existing power plants. In addition, many of the proposed plants will operate only during peaking hours so any impacts that may occur as a result of operating these plants will be less than if they operated all the time

However, there are a few impacts similar to those at existing power plants that may potentially occur at the proposed power plants and will need to be addressed. These problems primarily relate to those proposed plants that intend to burn coal, waste coal (also known as gob), or gasified coal with garbage. If these potential impacts are properly addressed, the information submitted to the Cabinet suggests that the proposed plants can be built without posing an unacceptable impact or risk to human health and the environment.

Recommendations:

To address the concerns identified at existing power plants and the impacts that may be caused by the proposed power plants, the Cabinet makes the following recommendations. Implementation of these recommendations will mitigate many of these concerns or provide the Cabinet with the necessary tools to protect human health and the environment.

a) The Cabinet should implement the NO_x SIP call and determine if additional NO_x or VOC reductions are necessary to eliminate 8-hour ozone concerns

b) The Cabinet should further analyze air toxics emissions occurring at all existing power plants to determine the extent of inhalation risks to humans and to determine the impacts caused by deposition and other exposures.

c) The Cabinet should develop air toxic standards that are protective of human health and the environment

d) The Kentucky legislature should remove the water withdrawal permitting exemption for power plants.

e) The Cabinet should continue to ensure that surface waters are not used as a drinking water source without adequate treatment.

f) Water discharge permits should establish limits for all constituents being released by a plant that have a potential to impact water quality. Currently, some permitted discharges only require monitoring without imposing specific limits on some of the discharged pollutants.

g) The Cabinet should establish groundwater standards.

h) The Cabinet should require monitoring at ash ponds to ensure that there are not pollutants being released from the ash pond into the groundwater.

i) Where groundwater at ash landfills or ash ponds is not safe for human consumption, the groundwater should be adequately treated before using the water as a drinking water source.

j) Special waste permitting requirements should be modified to ensure that there is adequate public participation before a new special waste landfill that will store power plant ash can begin operation.

k) The Cabinet's oversight of beneficial reuse should be more detailed, including groundwater monitoring at locations where ash is being used as a fill material

l) Additional study is necessary to determine the total number of power plants that Kentucky can accommodate and still be protective of human heath and the environment. Because this capacity is not known, the Cabinet will need to be diligent in its responsibilities to protect Kentucky's environment.

m) Additional staff are needed for conducting timely, comprehensive permit application reviews and for conducting oversight activities, such as inspections, monitoring and analysis, to ensure that all power plants currently located or built in Kentucky operate in a manner that is protective of human health and the environment.

n) Some environmental impacts are not directly related to power generation. Other activities conducted to support the electric generating industry, such as fuel extraction and transportation will have environmental impacts. The Cabinet was unable to evaluate these secondary impacts in detail. However, an analysis of the secondary impacts is necessary to fully understand the cumulative environmental impacts of power plant expansion.

"…The [Cabinet] is directed to study the cumulative environmental effects of the development of new electric generating capacity, as well as the resulting impact on existing environmental programs…"

Executive Order 2001-771

Introduction

Background

Kentucky has often been considered an ideal location for electric power generation. The significant coal fields, the location of natural gas lines and the many hydroelectric opportunities have led to the establishment of 34 separate electric generating power plants. The ever-increasing demand for electricity, in conjunction with changes in power generation regulation, has increased interest in constructing new generating plants in Kentucky. Since October 1999, the Cabinet has received applications for 22 new or expanding electric generating facilities. Based on these applications, if all of the proposed new or expanding facilities are constructed, the electric generating capacity in Kentucky would increase from approximately 18,000 megawatts to over 29,000 megawatts. The availability of reliable and inexpensive electricity does provide a substantial benefit to Kentucky's communities, but there is a cost to this power as well. Electricity generation can pose potentially harmful impacts to human health and the environment if the process is not managed to prevent environmental impacts. Each facility's location, fuel source, process, pollution control technology and waste management practices can have a negative impact on local communities and the health of the environment.

In order to evaluate the impact of an increase in Kentucky's electric generating capacity and to ensure that appropriate decisions are made, Governor Paul Patton, on June 19, 2001, declared a six month moratorium prohibiting the Cabinet for Natural Resource and Environmental Protection Cabinet from accepting additional applications for new generating facilities. During this time the Cabinet and the Public Service Commission (PSC) were required to study the impact of power generation in their respective areas of responsibility. This report was prepared in response to this directive.

Applicable Programs and Regulations

The Natural Resources and Environmental Protection Cabinet is directly responsible for issuing permits and overseeing many of the state environmental requirements imposed on power plants located in Kentucky. The Department for Environmental Protection, organized within the Natural Resources and Environmental Protection Cabinet, is given the primary responsibility for most of these regulatory programs. This includes the permitting and proper management of air emissions, wastewater discharges, water withdrawal, and solid, special and hazardous wastes.

Permitting requirements vary by plant, depending on plant size, fuel type and power generation process. Specific permits often required at power plants include: prevention of significant deterioration (PSD) and/or Title V permits for air emissions, permits for discharges to water, water withdrawal permits and special waste landfill permits for ash management. Additional permits that may be required, depending on plant specifications, include hazardous waste generation registrations, floodplains construction permits, dam construction permits, wild river utility right-of-way permits, groundwater protection plans, underground storage tank registrations, Section 401 water quality certifications and beneficial reuse permits.

The Kentucky laws that authorize these programs are found in the Kentucky Revised Statutes (KRS) Chapters 151 and 224; applicable regulations are located within Title 401 of the Kentucky Administrative Regulations (KAR). Many of these requirements are based on federal laws such as the Clean Air Act, the Clean Water Act, and the Resource Conservation and Recovery Act.

In addition to permits issued by the Cabinet, KRS 278.025 requires that when construction begins, all power plants under PSC oversight must obtain a Certificate of Environmental Compatibility. In order to obtain a Certificate of Environmental Compatibility, the power company must submit a statement of environmental compatibility to the Natural Resources and Environmental Protection Cabinet. The statement must address environmental and public health issues that could be caused by the proposed facility. The Cabinet reviews this submittal and based on this review makes a recommendation to the PSC on whether a Certificate of Environmental Compatibility should be issued.

Environmental Issues for Evaluation

Power plants have the potential to directly impact all of the environmental media - the air, water, and land resources. If uncontrolled or unmanaged, these impacts can also affect the health of Kentucky's. These impacts can affect the various plant and animal species that depend on Kentucky's natural resources. This report defines and analyzes a number of concerns in order to determine the cumulative impact associated with an expansion of electric generating capacity in Kentucky. Where specific data are available that measure the impacts caused by electric power generation, this report provides a quantitative analysis of these problems. Where inadequate or insufficient information is available, the Cabinet provides a qualitative analysis of the potential impacts.

Most of the potential impacts addressed by this document are directly associated with the generation of power. This document is divided into sections dealing with each of the media - air, water and land. Additionally, environmental impacts that are not directly caused by power plant operation are also discussed as indirect impacts.

Air emissions from certain types of power plants contribute compounds that form ground level ozone, haze, and acid deposition. Power plants can also emit particulate matter, metals, and other compounds that may have a detrimental effect on human and ecological health.

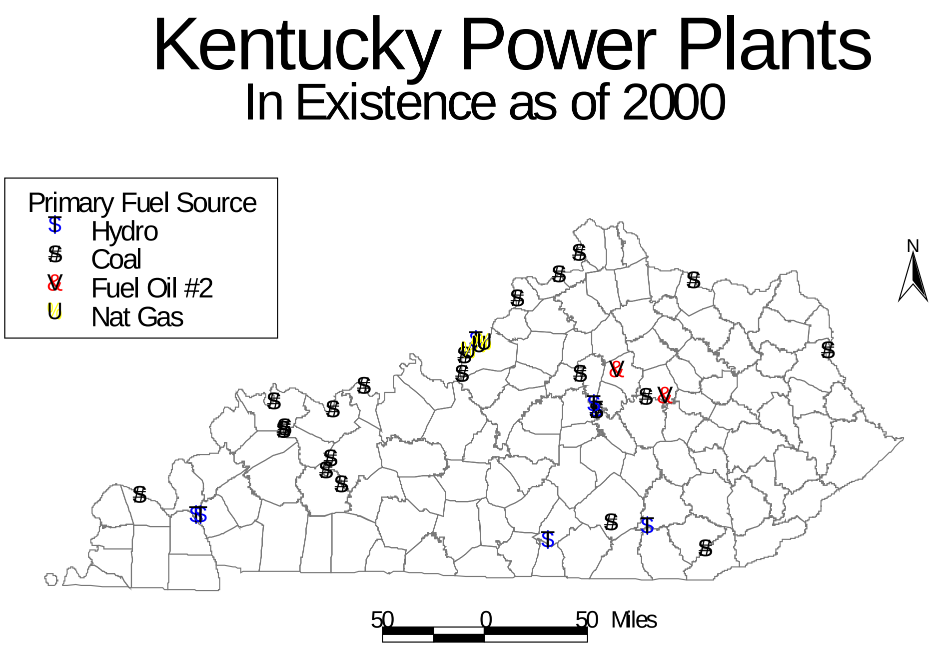
Power plants may also have negative impacts on water systems. Large quantities of water are often needed during the operation of power generation units depending on the generation process. This water consumption may reduce water availability for public water supplies, industrial use, agricultural use, and maintenance of stream ecosystems. Water is also discharged from these facilities. This includes water used as part of the electric generation processes, cooling water, and stormwater collected from the property surrounding the plant. This wastewater may contain pollutants that can adversely affect aquatic systems. The cooling process typical of gas, oil, and coal-fired facilities also increases the temperature of discharged wastewater, which can impact stream ecosystems.

Land quality can be impacted from plant siting as well as ash management. Siting issues include site stability and the proximity of power plants to sensitive areas such as communities and natural resources. Ash management is an issue because coal burning power plants generate large quantities of ash. This ash is disposed in ash ponds or special waste landfills. The ash may contain metals and other compounds that must be managed to reduce the threat to soil and groundwater.

There are also indirect impacts to the environment associated with electric power generation. Sixty percent of the coal burned by Kentucky coal burning power plants is mined in Kentucky[1]. Historically, coal mining has had extensive impacts on the environment. Some power plants burn oil and natural gas extracted from wells located in Kentucky. These wells can have adverse impacts on Kentucky's resources if improperly constructed and managed. To ensure the fuel is of an acceptable quality for electric generation, fuel processing and refinement is often necessary. This refinement process can produce pollutants and wastewater that contributes to environmental problems. Barges, rail systems, and gas pipelines are all frequently used as methods to transport power plant fuel. Each of these can cause extensive impacts to the quality of Kentucky's environment. There are also potential indirect impacts associated with the construction and operation of a power plant. Facility construction itself may cause the permanent loss of wetlands or other unique habitats. Once operating, plant noise and an increase in traffic may disturb local residents.

All of these issues will be explored in more detail within this report. However, the bulk of the Cabinet's efforts are focused on the impacts directly attributable to the operation of power plants.

Power Plant Summary



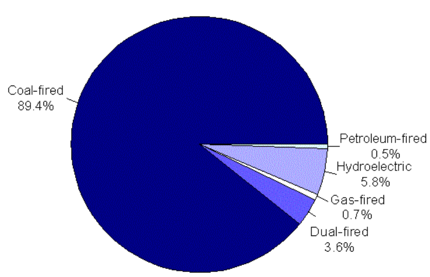
PLANT	COUNTY	POWER PRODUCTION	MANUFACTURER CLAIMED CAPACITY (Megawatts)	PRIMARY
East Bend	Boone	Baseload	648.4	Coal
Cooper	Pulaski	Baseload	320.9	Coal
Dale	Clark	Baseload	176.0	Coal
H L Spurlock	Mason	Baseload	813.5	Coal
J.K. Smith	Clark	Peaking	330.0	Fuel Oil #2
Henderson I	Henderson	Unknown/Peaking/Baseload	46.2	Fuel Oil #2/Coal
Big Sandy	Lawrence	Baseload	1096.8	Coal
Dix Dam	Garrard	Baseload	28.2	Water
E.W. Brown	Mercer	Baseload/Peaking	1243.5	Coal/Natural Gas
Ghent	Carroll	Baseload	2226.1	Coal
Green River	Muhlenburg	Baseload	263.6	Coal
Haefling	Fayette	Peaking	62.1	Fuel Oil #2
Lock 7	Mercer	Unknown	1.9	Water
Pineville	Bell	Peaking	37.5	Coal
Tyrone	Woodford	Peaking/Baseload	137.6	Fuel Oil #2/Coal
Cane Run	Jefferson	Baseload/Peaking	660.9	Coal/Natural Gas
Mill Creek	Jefferson	Baseload	1717.2	Coal
Ohio Falls	Jefferson	Baseload	80.0	Water
Paddy’s Run	Jefferson	Peaking	190.5	Natural Gas
Trimble County	Trimble	Baseload	566.1	Coal
Waterside	Jefferson	Peaking	45.0	Natural Gas
Zorn	Jefferson	Peaking	19.4	Natural Gas
Elmer Smith	Daviess	Baseload	438.0	Coal
Kentucky	Marshall	Baseload	197.6	Water
Paradise	Muhlenburg	Baseload	2558.0	Coal
Shawnee	McCracken	Baseload	1750.0	Coal
Barkley	Lyon	Unknown	130.0	Water
Wolf Creek	Russell	Peaking	270.0	Water
Laurel	Laurel	Peaking	70.0	Water
Coleman	Hancock	Baseload	495.0	Coal
Green	Webster	Baseload	484.0	Coal
Henderson 2	Henderson	Baseload	350.0	Coal
Reid	Webster	Peaking	70.0	Fuel Oil #2
Wilson	Ohio	Baseload	440.0	Coal

Status of Existing Generating Units

Currently there are 34 power plants operating in Kentucky that collectively produce approximately 18,000 megawatts of power. Four are peaking plants, four are a combination of baseload and peaking plants, and the rest are baseload plants. Less than ten percent of the existing electric generating capacity is generated by peaking plants, which operate only during periods of high demand. The rest of the Commonwealth's electric generating capacity comes from baseload plants, which operate all day, year-round.

The majority of existing power plants generate power by heating water to produce steam. The steam is put under pressure to turn turbines that produce electricity. Twenty-two plants currently operating in Kentucky burn coal in the steam generation process. Five of these plants also burn either natural gas or fuel oil. Roughly 16,600 megawatts is produced by coal-burning facilities. There are seven hydroelectric plants currently operating in Kentucky. The current generating capacity of the hydroelectric plants is approximately 780 megawatts. There are three natural gas plants. These plants generate approximately 250 megawatts of power. The remaining two power plants burn fuel oil as their primary fuel source and generate nearly 400 megawatts of power.

Utility Generating Capability, by Plant Type, 1998



Source: USDOE, Energy Information Administration

The 22 coal-burning facilities consume a large quantity of Kentucky coal each year. Of the 39,258,000 tons of coal used for electricity generation in Kentucky in 1999, 24,558,000 tons, or 63 percent were mined in Kentucky.

Most of the power plants currently operating in Kentucky were built more than twenty years ago. Only four power plants have been built since 1980. The construction of new units at existing plants has also been limited. Only four existing plants have added one or more units during the last 20 years.

In addition to differences in operation and fuel types, there is also significant variation in the individual generating capacity of each plant. Approximately 65 percent of the electricity generated in Kentucky each year is generated by the seven largest power plants in the state. The remainder of the existing plants are relatively small and only generate a limited amount of electricity. The generating capacity of a power plant is important from an environmental impact perspective because often the plant size and type of fuel being burned will give an indication of the type of impacts that could be expected.

Kentucky's Ten Largest Power Generating Plants

Plant	Generating Capacity (MW)
Paradise	2558.0
Ghent	2226.1
Shawnee	1750.0
Mill Creek	1717.2
E.W. Brown	1243.5
Big Sandy	1096.8
H L Spurlock	813.5
Cane Run	660.9
East Bend	648.4
Trimble County	566.1

During the last five years, there have been over 600 inspections conducted at the 34 power plants currently operating in Kentucky. An inspection includes any time that a Department for Environmental Protection employee or a Jefferson County Air Pollution Control District employee visits a power plant to evaluate if the plant is operating in accordance with all applicable air, water, and waste management regulations. Typically, an inspector will focus the evaluation on a specific permit or type of ongoing operation. However, at times, more comprehensive evaluations are conducted. During the last five years, hydroelectric dams were the least frequently visited type of power plant. Coal-burning facilities were the most frequently inspected plants. Some coal-burning plants were visited on average more than seven times a year.

There have been approximately 75 violations that have been identified at Kentucky's power plants since 1997. Cabinet records show that almost all of these violations were minor and did not pose a direct threat to human health or the environment. Examples of violations that would be considered minor include failure to keep appropriate records or to submit information within a required timeframe. There were a few violations noted that were considered to be more significant. These violations included small petroleum spills, wastewater discharge violations, inappropriate operation of equipment, and excess air emissions. All of these violations have been adequately addressed and the problems corrected.

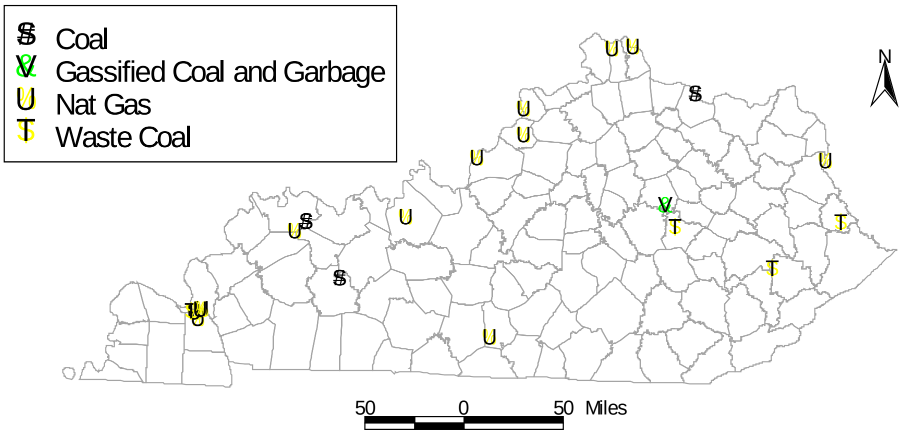
Status of Proposed Generating Units

The Cabinet is currently processing various permit applications for proposed power plants. The Cabinet has received applications for the construction of 22 new or expanded power plants. After the moratorium expires, it is likely that more applications will be received for additional plants. Some of the 22 plants are already under construction; others are still in the conceptual stages and, even if all of the applicable permit applications are approved, many will not begin operation for some time. The proposed plants are different in many regards from the existing plants located in Kentucky.

The first difference is that a greater number of proposed plants will operate as peaking plants, rather than baseload plants. Based on applications submitted to the Cabinet, 12 of the 22 new or expanding plants are peaking plants, which will only operate during times of high demand. If all of the proposed plants are constructed as currently designed, collectively they will generate approximately 11,000 megawatts of power. Of this cumulative total, peaking plants will generate approximately 50 percent of this energy.

The second difference is that the proposed plants will burn less coal and more natural gas. Currently, most of the plants operating in Kentucky are coal-fired plants. Of the power plant applications being considered by the Cabinet, 14 will burn natural gas as their primary fuel. Four plants are proposed that will burn waste coal, also referred to as gob. Two plants will burn traditional coal, and one plant will burn a combination of gasified coal and residential garbage.

Kentucky Power Plants
Proposed Constructions or Expansions
Since 10/01/1999



PLANT	COUNTY	POWER PRODUCTION	MANUFACTURER CLAIMED CAPACITY (Megawatts)	PRIMARY
Dayton Power and Light	Breckenridge	Peaking	400.0	Natural Gas/Oil
Trigen – Cinergy Solutions of Silver Grove	Campbell	Peaking	20.0	Natural Gas
East Kentucky Power – J.K. Smith Station	Clark	Peaking	312.0	Natural Gas/Oil
Global Energy – Kentucky Pioneer Energy	Clark	Baseload	540.0	Gasified Coal/Gasified Garbage
Calla Energy	Estill	Baseload	110.0	Waste Coal
Columbia Electric Corp. – Grane Creek	Henderson	Peaking	500.0	Natural Gas
Cash Creek Generation	Henderson	Baseload	1000.0	Coal
LG&E – Paddy's Run	Jefferson	Peaking	151.0	Natural Gas
Cinergy – Erlanger	Kenton	Peaking	96.0	Natural Gas
Enviropower – Kentucky Mountain Power	Knott	Baseload	500.0	Waste Coal
Dynegy – Riverside Generation	Lawrence	Peaking	1040.0	Natural Gas
Air Products and Chemicals	Marshall	Cogeneration	26.0	Natural Gas
Duke Energy – Marshall County Generation	Marshall	Peaking	640.0	Natural Gas/Oil
Enron – Calvert City Power	Marshall	Peaking	540.0	Natural Gas
Westlake Energy	Marshall	Cogeneration	520.0	Natural Gas
Enviropower – Kentucky Western Power	Marshall	Baseload	500.0	Waste Coal
Enviropower – Kentucky Eastern Power	Martin	Baseload	500.0	Waste Coal
East Kentucky Power – Spurlock	Mason	Baseload	270.0	Coal
Duke Energy – Metcalfe County Generation	Metcalfe	Peaking	640.0	Natural Gas/Oil
Thoroughbred Generating	Muhlenberg	Baseload	1500.0	Coal
Dynegy- Bluegrass Generation (Phase I & II)	Oldham	Peaking	624.0	Natural Gas
LG&E – Trimble Station	Trimble	Peaking	1020.0	Natural Gas

Methodology

In preparing this report, the Cabinet used standard investigative procedures for collecting and analyzing data associated with power plants. Where uncertainties existed, conservative assumptions were used to be protective of human health and the environment. Data gaps were filled using surrogate data, extrapolations, or best professional judgements and are documented in the appendices. Exposures of humans and the environment to pollutants were estimated using typical risk assessment limits that included average and upper-bound values.

Air Analysis

Criteria air pollutants were modeled using the Community Multiscale Air Quality (CMAQ) system to evaluate statewide impacts of power plants on air quality. The model was run on a limited time period (July 9-16, 1995) due to the tight study schedule. This time period had been used for the Southern Oxidant Study (SOS) and was considered conservative. Meteorological conditions and plant activities were favorable to ozone formation during this period, and violations of the ozone standards occurred in metropolitan areas and statewide. The model considered point sources, mobile sources, area sources, and biogenic sources. It was run using a 4-kilometer grid as the highest resolution. Following a baseline run, the proposed power plants were added for comparison. The model was also run without existing power plant emissions to estimate the impact of already existent plants on air quality. Sources added since 1995, other than power plants, were not considered and reductions in pollutant emissions since 1995 were also excluded. In addition, plants proposed in states near Kentucky's borders were not included in the baseline. It was also assumed that all of Kentucky's power plants would be built and would be at peak production in summer dates examined. The modeling results were evaluated to estimate potential impacts of the Commonwealth's existing and proposed plants on the 1-hour and 8-hour ozone standards, NOx levels, fine particulate matter totals, and visibility.

Air toxics were evaluated for a subset of the existing and proposed power facilities. Plants were selected based on type of fuel, location, and size so that every fuel type was represented and results could be extrapolated to other similar plants. Plants in Jefferson County were not analyzed, however, inferences were made based on modeling of plants similar to the facilities in Jefferson County. The chemical compounds used for the air modeling were selected based on power plant emission quantity and toxicity. The toxicity was represented by the risk-based screening value (RBSV) for each contaminant. This is discussed in detail in the appendices. Under these criteria, thirteen toxic air pollutants were selected for evaluation. Twenty power plants and five clusters, where several plants are located close to each other, were modeled in the air toxics evaluation.

The ISC-Prime model was selected to estimate ambient annual air concentrations. A ten kilometer radius from the plants was evalutated, with the exception of the Muhlenburg County cluster, where a fifteen kilometer radius was used. ISC-Prime is approved by the U.S. EPA for near range ambient air modeling. Emissions data were obtained from owner/operators of existing plants or from permit applications for proposed plants. To fill data gaps, U.S. EPA AP-42 emission factors for coal, fuel oil, or natural gas combustion were used as appropriate. Meteorological data were obtained for Paducah and Jackson for sites in Western and Eastern Kentucky. Huntington, W.V. weather data was used for two power plants in Lawrence County. All polycyclic aromatic hydrocarbons (PAHs) were assumed to be benzo(a)pyrene. Duke Energy was modeled assuming a worst case scenario of burning fuel oil even though natural gas is expected to be its primary fuel. Ambient air concentrations were plotted to show the exceedance of the RBSV for each air toxic. Because of the potential for additivity of effects from toxicity, the exceedance of one-tenth of the RBSV was also plotted. Multiples of the RBSV (ten times, twenty times, etc.) were plotted to show the areas of higher risk.

Water Analysis

The first evaluation of impacts to the water resource from power plants was an analysis of the quantity of water withdrawn from streams. The data were obtained from KPDES permit applications, the water withdrawal program, or were voluntarily submitted by the plants. The intake flow was compared to the stream flow to identify the percentage of stream flow that is used by the power plant.

The impact on surface water from permitted discharges was evaluated using Discharge Monitoring Reports (DMR) for the period from 1997 to 2001. Monitored parameters with the highest potential for toxicity were metals and Polychlorinated Biphenyls (PCBs). Other compounds that could be in outfalls, including organics, are not monitored or reported. Data were not reported for all sampling events for each chemical. The outfall data was compared to human health risk-based screening values based on tap water ingestion, recreational use of the water, and Warm Water Aquatic Habitat Criteria from 401 KAR 5:031 for ecological receptors. Maximum Contaminant Levels were used to evaluate compliance with drinking water standards. Since use of the surface water as a domestic water supply would be preceded by chemical/biological treatment, this is a conservative assumption. The data were analyzed using undiluted outfall as a worst case scenario, and with a dilution factor to estimate concentration of contaminants after initial dilution. The dilution factor was derived using one-third of the stream flow rate, to represent partial mixing, and then dividing by the average annual flow rate of the outfall. The harmonic mean was used for human health impacts to represent chronic exposure to the water. The 7Q10, the 7 year low flow condition, was used for ecological receptors. The outfall concentration was divided by the dilution factor to represent partial mixing. Cumulative impacts from multiple outfalls at a facility were not evaluated. Flow rates for the outfalls were only available for selected outfalls and were extrapolated to represent other outfalls at the facility. Analysis was completed for existing plants and inferences were made for proposed plants.

Violations of permit limits were also evaluated for the outfalls. Permit limit violations for parameters that are "monitor only could not be evaluated. The KPDES permits require toxicity testing for 19 existing plants. The DMR data and the Division of Water's ToxTrac database were evaluated to determine exceedance of permit limits of 1.0 Toxicity Units, the unit of measurement for toxicity testing.

The impact of power plants on groundwater was evaluated as part of the waste evaluation.

Waste Analysis

The primary solid waste associated with coal-fired power plants is ash in the form of fly ash, bottom ash, and slag. Scrubber sludge and other byproducts of coal combustion comprise the remaining solid waste associated with power plants. The impacts associated with power plant wastes were analyzed with regard to effects on groundwater. . Of primary concern to the study is ash discarded in landfills. The landfill for a single representative power plant was evaluated. The Mill Creek Station for Louisville Gas and Electric was selected based on the size of the facility and the landfill, and because the landfill contains primarily ash and scrubber waste. In addition, the special waste landfill is unlined, so this selection would be conservative for inferring impacts of power plant wastes on groundwater. Groundwater monitoring data from 1991 to 1996 were compared to human health risk-based screening values based on ingestion of tap water, and to Maximum Contaminant Levels, values for compliance with drinking water standards. The groundwater sampled was from below and slightly downgradient from the landfill and was obtained from monitoring wells and production wells. The groundwater for this facility is not currently used as a domestic source of drinking water. Wells used for domestic use would be installed further downgradient than the monitoring wells where greater dilution could occur. Ash pond effluents were evaluated in the surface water study. Groundwater impacts from ponds were not evaluated in the study, but have the potential for leaching into the groundwater from ash ponds depending on the permeability of the ash pond substrate.

Risk Assessment

Risk assessment methods developed for environmental analysis were used to produce target concentrations in tap water, surface water, and air. These concentrations were derived based on the methods described in Appendix G. The RBSVs are based on exposure of highly sensitive people, such as infants or the elderly, for a reasonable maximum exposure. The toxicity of the compounds that were evaluated were represented by values obtained from the U.S. EPA Integrated Risk Information System (IRIS), the Health Effects Assessment Summary Tables (HEAST), the National Center for Environmental Assessment (NCEA), and other U.S. EPA sources.

Waste Generation and Disposal

In 1999, Kentucky facilities released nearly 106 million pounds of toxic substances. Slightly more than 12 million pounds were transported off-site for disposal. The remaining 94 million pounds of these toxics were released on-site. This includes on-site emissions released to air, water, and land[2].

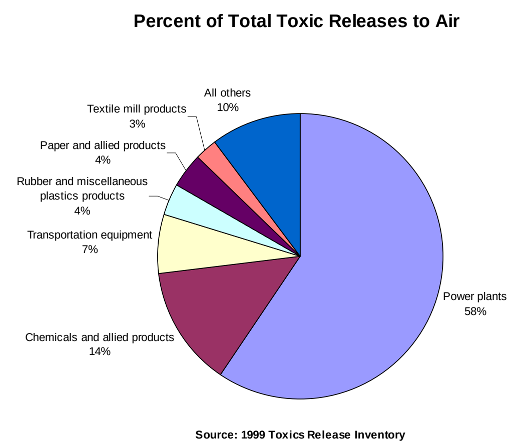
1999 was the first year that electric generating units were required to report their releases to the Toxics Release Inventory (TRI). The inventory indicates that based on the total volume of toxic waste released on-site in 1999, nine of the top ten facilities in Kentucky were electric generating units. In fact, as a whole, power plants released more toxic substances on-site than all other TRI reporting facilities combined.

Top Ten On-Site TRI Releases by Kentucky Facilities[3]
(Air, Water, and Land)

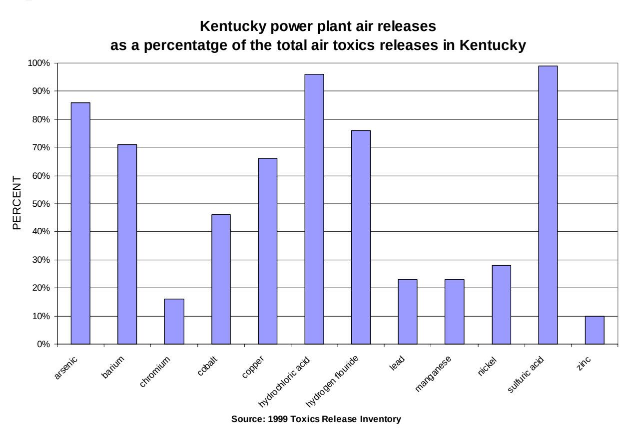
Facility, County	Total On-Site Releases (lbs/yr)
U.S. TVA Paradise Fossil Plant, Muhlenburg	12,174,045
Ghent Station, Carroll	10,204,182
Big Sandy Plant, Lawrence	8,449,417
Spurlock Power Station, Mason	4,682,659
E. W. Brown Station, Mercer	3,860,449
U.S. TVA Shawnee Fossil Plant, McCracken	2,957,295
Coleman, Hancock	2,515,683
Mill Creek Station, Jefferson	2,201,463
Air Prods. & Chemicals Inc., Marshall	2,185,316
Cooper Power Station, Pulaski	2,125,692

Air Releases

About half of the on-site toxic releases occurring at power plants are released into the air. In 1999, over 44 million pounds of air toxics were released by power plants. This accounts for nearly 60 percent of all air toxic releases reported in the Commonwealth. The total amount of toxics released into the air by all of Kentucky's industries was approximately 75 million pounds[4].



The primary sources of air toxic releases were coal-fired power plants. The primary air toxics released from coal-fired power plants as reported on the 1999 TRI were hydrochloric and sulfuric acids. These two chemicals accounted for 96 percent of the total air toxics reported by these plants on the 1999 inventory. Coal-fired power plants produced more than half of the total reported volume of arsenic, barium, copper, hydrochloric acid, hydrogen fluoride, and sulfuric acid released into Kentucky's air. In the case of hydrochloric and sulfuric acid more than 95 percent of the total air emissions for these two chemicals in the state came from power plants[5].

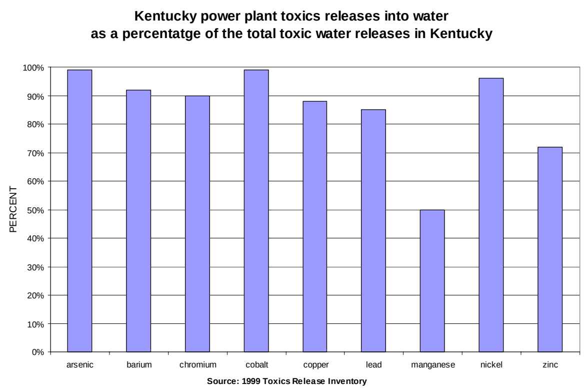


In addition to toxic releases, power plants emit large quantities of other air pollutants. These pollutants are commonly referred to as criteria air pollutants. In 1999, power plants released approximately 300,000 tons of nitrogen oxides (NO_x) into the air. This accounts for 44 percent of the total NO_x released in the state. This compares to 280,000 tons released by automobiles and 115,000 tons from all other sources combined. Power plants also accounted for more than 600,000 tons of sulfur dioxide (SO_2) released into the air. This accounts for 84 percent of the total amount of SO_2 released in Kentucky. Power plants have also been documented to be sources of carbon dioxide (CO_2), carbon monoxide (CO), and particulate matter.[6]

It is not anticipated that proposed plants fueled by natural gas will cause a significant increase in toxic releases. Natural gas plants have lower emissions and release fewer contaminants. However, it is expected that the proposed new plants that burn coal or waste coal as the primary fuel will cause these air toxics release values to increase. All of the proposed new or expanding power plants will have the potential to release criteria air pollutants. This will result in an increase in the criteria pollutant volumes.

Water Discharges

Similar to air releases, power plant water discharges make up a significant percentage of the total toxic releases into Kentucky's water systems. According to the 1999 TRI, power plants contribute over 40 percent of the total toxic chemicals released into the water. These releases are two times greater than the next closest industrial group. Unlike the air TRI emissions for power plants, which primarily consisted of hydrochloric and sulfuric acids, the water discharges from coal-fired plants are predominately nitrate compounds (68 percent of the releases) and assorted metals (31 percent of the releases). Relative to the rest of the toxic waste discharged to water in the state as reported by TRI, coal-fired power plants contribute a significant proportion of some of these chemicals to the environment. The table below indicates that coal-fired power plants contribute nearly all of the arsenic, barium, chromium, cobalt, copper, lead, and nickel released to the waters of the Commonwealth. It should be noted that not all facilities in the state report to the TRI. This should not be considered a comprehensive inventory of all toxic releases.



In addition to toxic releases, many power plants release other wastewater contaminants contributed by sanitary wastewater, stormwater, or process water. One discharge impact that is not always thought of as a traditional pollutant is heat. Often, process water is returned to a stream at higher temperatures than it was withdrawn. This change in temperature can have an adverse effect on the stream system and the plants and animals that reside in and around it.

As with air releases, it is not expected that new natural gas burning plants will contribute a significant increase in the amount of toxics released to water. It is reasonable to expect that new coal or waste coal burning plants will contribute similar releases and increase the amount of toxics released into the streams. In addition, all plants, natural gas and coal burning, that discharge wastewater back into a receiving stream will potentially cause an impact because the discharge will likely be at elevated temperatures.

Solid Waste

The dominant solid waste generated at power plants is ash. The ash generated as part of electric generation is a waste product produced from coal combustion at coal burning power plants. Throughout this report, the term "ash" is used to refer to the waste generated by the combustion process. Use of the word ash simplifies the narrative, but it is not entirely accurate. Where references to "ash" are made, it should be considered to be synonymous with "coal combustion by-products," as defined by Kentucky waste regulations. This material can include non-coal minerals, non-combusted coal, and other combustion and pollution control technology wastes, such as fly ash and bottom ash, that is generated when coal is burned. Slag is the portion of the coal waste that becomes viscous at burner operating temperatures. It is often recovered in the molten state and placed in water where it becomes a glassy, angular material. Fly ash is the part of the coal combustion particles that are transported up the flue, most of which is retained in the pollution control equipment. Bottom ash is dry ash that does not melt but is too heavy to be captured in the flue gas. It is recovered from the bottom of the boiler. This is sometimes combined with slag. Scrubber sludge is material generated by flue-gas desufurization "scrubbing" methods[7].

The type of fuel used to generate the electricity has a big impact on the amount of ash generated at a power plant. Existing coal-fired units produce ash at a rate of approximately 10 to 15 percent of the weight of the coal burned. For the proposed plants that will burn waste coal, the combustion waste will include a considerable burden of non-combustible, non-coal minerals. As much as fifty percent of the fuel material introduced into a waste coal burner will be removed as waste. The existing coal fired plants create approximately 9 million tons of ash per year. Information furnished to the Cabinet suggests that the proposed plants will produce 15 million tons of ash per year.

Due to the large volume and the presence of several pollutants, most notably metals such as arsenic, cadmium, copper, and mercury, management and disposal of ash has significant potential for environmental and land use impacts. Coal combustion byproducts, or ash, may also include lime or limestone from pollution control devices, and limestone or sand from fluidized bed combustion. The implementation of Selective Catalytic Reduction (SCR) systems, while lowering air emissions of nitrogen oxides, may also result in ammonia in ash and wastewater, creating additional concerns for proper management.

In addition, the amount of naturally occurring radioactive material (NORM) in coal varies by type of coal and location from which it is mined. Much of this radioactivity remains in the fly ash after the coal combustion process. Fly ash can contain two to seven times as much radioactivity as rocks and soil. Although this is true, fly ash is not considered to be a significant radiological health hazard. The gamma radiation from fly ash is considered a negligible source of radiation to the human population, and is presumably the same to wildlife[8].

According to reports submitted to the Division of Waste Management, approximately seven of the nine million tons of ash generated annually are discarded in landfills or ponds. The other two million tons are reused in a variety of applications, including use in concrete, gypsum wallboard, abrasives and roofing granules, highway base course, anti-skid material applied to roads and parking lots, sludge stabilization and structural fill.

<u>Other Wastes of Interest</u>

Data does not exist for all potentially emitted wastes generated by power plants. A chemical that was not reported by power plants on the 1999 TRI is mercury. Mercury emissions can have a significant impact on the environment, particularly in aquatic ecosystems. Even when emitted at low levels that would not directly cause a negative impact, mercury has the ability to accumulate over time within the environment and to bioaccumulate.

Bioaccumulation occurs when an animal eats an organism with a bioaccumlative compound in its system, such as mercury or cadmium, and absorbs that compound into its own system. The more contaminated organisms that are eaten, the greater the accumulation of that compound. This accumulation process becomes more pronounced the higher one goes in the food chain. Kentucky currently has a statewide fish consumption advisory because of low levels of organic mercury found in samples of fish from Kentucky waters. Details on this advisory can be found in Appendix I.

Beginning in 2000, power plants were required to report mercury emissions as part of the TRI. Although unverified, early release, year 2000 TRI data from industry submitted to the Cabinet indicate that over 1,400 pounds of mercury were released to surface impoundments from power plants. An additional 3,546 pounds of mercury was released from air stacks, which presumably settles on the land or in the water. Kentucky is ranked as one of the top ten states for the release of mercury originating from power plants[9].

Another potential chemical release that the Cabinet will be evaluating over the next few years is nitrogen. It is anticipated that some of Kentucky's existing power plants will be installing new SCR units over the next few years. These devices use ammonia (NH_3) to decrease a plant's NO_X emissions.

Since Nitrogen Oxides, or NO_X are a major component in the formation of Ozone, limiting the formation and emission of this compound is critical to air quality improvement. As major sources of NO_X, fossil fuel-burning electrical generators employ a number of different control strategies and devices to reduce their emissions. Selective Catalytic Reduction (SCR) is one approach to NO_X reduction.

SCR technology involves injecting ammonia into boiler flue gasses and passing it through a catalyst bed where the ammonia reacts with existing NO_X to form simple nitrogen and water vapor.

Not all of the ammonia that is injected into the boiler reacts with the NO_x. In this case, the excess ammonia is captured in the ash or emitted out of the plant's stack. The amount of ammonia that makes it through the SCR without reacting is known as ammonia slip.

Whether air deposited, or leached from treatment ponds, or landfills, excess nitrogen in water systems can have numerous negative impacts. The effects range from health concerns for drinking water to encouraging general eutrophication of lakes and rivers. Because these SCR units are just now beginning to be installed on some of Kentucky's existing power plants, it is uncertain how much nitrogen will be generated statewide as a result of operating these pollution control devices.

Actual SCR configurations, catalysts employed and ammonia use (flow rates) will vary from unit to unit. Actual NO_X reduction achieved will also vary, but some testing indicates the NO_X removal rate of up to 80 percent is achievable. Two fossil fuel electrical generating plants in the Commonwealth currently employ SCR technology.

Waste Consumption

Even though power plants generate a large amount of waste as a byproduct of the electricity generation process, they also present opportunities to assist in statewide waste management.

Owensboro Municipal Utilities is burning processed waste tires mixed with coal. Waste tires have been a significant waste management problem in the past. Use of this material in the electric generation process will reduce some of the adverse environmental impacts caused by waste tires such as the potential for toxic fires and infestations of disease carrying animals, such as rats and mosquitoes.

Four of the new proposed plants also plan to use another traditional waste material as a fuel source. Calla Energy, Kentucky Mountain Power, Kentucky Western Power, and Kentucky Eastern Power all are planning to burn waste coal, also known as gob. This low quality fuel is a byproduct of mining and is directly related to how and where the coal seams were formed. The region of the world, and materials available during formation, determines the quality of the coal and the types and amounts of extraneous materials contained within and around the coal seam. Mining removes both the coal and less desirable materials such as silica and alumina oxides (sand), sulfur, and other minerals. Most mining operations wash their coal to eliminate these non-combustible materials and then store this debris, or gob, in open piles on the mining site. Current coal-washing techniques also cause some carbon, or fine coal, to be removed from the mainstream coal. The sand in the gob has no heating value, but the coal fines do. The gob pile is harvested for this fractional fuel value for use in fluidized bed furnaces and is mixed with some mine coal to ensure adequate heating value during combustion.

The composition of gob piles varies from mine to mine, and most gob burning facilities will contract with several different mines to supply their waste coal needs. Since all gob currently proposed for use in Kentucky power plants originates in Kentucky, some general content observations may be made. A recent check of the U.S. Geologic Survey database shows that Eastern Kentucky coal, in general, contains between 11 and 25 percent silica and alumina oxides (or ash), averages 12,609 BTU heating value per ton, and contains an average of 3.39 ppm of beryllium, 0.19 ppm of mercury, and 9.31 ppm of lead. An analysis of random gob piles in Eastern Kentucky showed an average of 4,879 BTUs per ton of gob. The gob piles also showed an average ash content of 48.17 percent, and 2.46 ppm beryllium, 0.32 ppm mercury, and 30.12 ppm for lead. The high percentage of lead can probably be attributed to the fact that lead is likely to settle out of the mainstream coal as it is washed. Western Kentucky coal also has a much higher BTU value than gob.

Through the use of new technology, these four proposed power plants will turn gob into a resource. This will allow Kentucky to rid itself of many of these often unsightly and previously unwanted piles.

Another plant that is planning on converting a traditional waste into a resource is Kentucky Pioneer Energy. This plant will use a technology that will burn traditional household garbage along with gasified coal to generate electricity. The garbage will be processed into pellets prior to use as a fuel. The processed garbage will be mixed with coal at a 50/50 mix and will produce a total BTU content of 9,000 BTU per pound. Traditional disposal of this waste would be in a municipal landfill.

All of these waste consumption technologies require caution. The Cabinet encourages the beneficial reuse or recycling of traditional waste provided that it does not adversely affect human health or the environment. When using these materials as a fuel in the electric generation process, it is important that proper pollution control technologies be utilized to ensure that there are not unhealthy levels of air, water, or land pollutants being generated. The Cabinet will carefully evaluate these proposals and monitor constructed facilities to ensure that they do perform as proposed without adverse impacts to the Commonwealth.

Air Quality Impacts

Air pollution is hazardous to human health and the environment. It can irritate and damage the respiratory system and may produce long-term or chronic illnesses. People who have underlying health problems such as asthma and emphysema, the very young, the elderly, and people who work outdoors are more susceptible to the harmful effects of air pollution. Trees, crops, and other vegetation can be damaged by air pollution and some air pollutants can also damage buildings, monuments, and other man-made structures. Visibility in many of our national parks and forests is hindered by air pollution.

The Clean Air Act, last revised in 1990, is designed to protect and enhance the quality of the nation's air resources so as to promote the public health and welfare and the productive capacity of its population. The Clean Air Act mandates how the U.S. Environmental Protection Agency (EPA) and states address air quality issues and mandates that certain requirements be met. However, U.S. EPA allows states the flexibility to develop programs that meet the state's needs, while still meeting the federal requirements. U.S. EPA must develop programs and promulgate regulations to ensure the intent of the act is implemented nationally. States must use the best and most reasonable methods available to ensure the requirements of the act and the regulations adopted by U.S. EPA are implemented.

The act mandates that the U.S. EPA develop and set air quality standards to protect human health and the environment within an adequate margin of safety. This phrase is important in setting the standards. It means that not only are healthy citizens protected from adverse impacts of air pollution, but that the state must protect those individuals most susceptible to the harmful effects. The act specifies that preventative measures be taken to maintain air quality in areas that meet the standards and provides specific requirements for areas that do not meet the air quality standards.

EPA has set standards for several pollutants that are typically referred to as "criteria" pollutants. Those standards are called National Ambient Air Quality Standards (NAAQS). Standards have been set for sulfur dioxide, carbon monoxide, nitrogen oxides, lead, ozone, and particulate matter. U.S. EPA is required by the act to review those standards every five years and make a determination that the level of the standard, based on most recent studies, is adequate to protect the public health and environment. Based on those studies, U.S. EPA is required to revise the stringency of the standards. U.S. EPA has also set standards for some hazardous air pollutants, known as the National Emission Standards for Hazardous Air Pollutants (NESHAPS). Standards were set for arsenic (inorganic), asbestos, beryllium, mercury, vinyl chloride, benzene and radionuclides. In each case, these standards apply only to specifically named sources of these pollutants. NESHAPS continue to apply to both old and new sources of the regulated pollutants.

The 1990 Clean Air Act Amendments, included a list of 189 substances (since revised to 188) which are considered hazardous air pollutants. The act mandated that U.S. EPA develop a list of categories of source types for regulation of these substances. Based on that list, U.S. EPA issues Maximum Achievable Control Technology (MACT) standards for source types. These standards, once adopted, represent the technology based emissions requirements for major and area sources.

In addition to providing U.S. EPA with the authority to set air quality standards, the Clean Air Act mandates that states make plans and implement programs to meet and maintain the ambient air quality standards and the provisions of the act, where appropriate. That plan is known as the State Implementation Plan (SIP).

The Clean Air Act also contains provisions that allow states to issue permits to air polluting facilities. KRS 224:10-100 provides the Cabinet with the authority and duty to carry out a permitting program for air pollution sources within Kentucky. Further, authorizing regulations to require permits for air pollution sources in Kentucky are found in 401 KAR Chapter 52. Each industry, depending on its potential emissions level, must obtain a permit to construct and operate that facility. If the application for the permit provides reasonable information that the facility can meet all regulatory requirements, the permit must be issued. In some instances, this includes a case by case review of very large emitting sources (typically those expected to emit 250 tons a year or more) referred to as PSD (prevention of significant deterioration) sources. Specific requirements exist for these sources, including stringent Best Available Control Technology (BACT) emission controls and a demonstration that air quality will not be substantially altered. Permits issued under the air quality programs, must also contain any federal requirements that may be different from the state's. Permits for large sources that may have emissions that potentially impact visibility in areas classified as Class I areas (national parks and forests such as Mammoth Cave and the Great Smokey Mountains) must also be reviewed by the Federal Land Managers.

Although U.S. EPA has issued NAAQS for several pollutants, of particular concern in Kentucky are the potential impacts from power plant emissions on ozone and particulate levels and any additional risks from an increase in hazardous air pollutants. Another concern is impact to visibility in the Mammoth Cave National Park, a designated Class I area. The emissions of concern are volatile organic compounds (VOCs), nitrogen oxides (NO_x), fine particulate matter and various hazardous air pollutants.

Carbon dioxide (CO_2) is one of many pollutants that contribute to a phenomenon known as Global Warming. Of regional and national concern are the existing emissions of CO_2 and the additional emissions that will come from electrical power generation. Fossil fuels burned to run cars and trucks, heat homes and businesses, and power plants are responsible for about 98 percent of the U.S. CO_2 emissions. Continued debate on the impacts of CO_2 and whether to control this pollutant from electric generating utilities is ongoing at a national and international level.

One of the most useful mechanisms for gauging potential impacts from emission increase or reduction is the use of mathematical models. These sophisticated computer programs use elaborate sets of equations to predict changes in pollutant levels due to a variety of scenarios. To forecast impacts on ozone, special models called photochemical models are used due to the complex chemical transformations that take place in the formation of ozone. Predictive models are designed for use in regional analysis and are not for source specific applications.

U.S. EPA's Atmospheric Modeling Development Branch (AMD), at the request of Kentucky, performed a series of model simulations with the Community Multi-Scale Air Quality (CMAQ) modeling system to examine the potential air impacts of adding new electrical generating units in Kentucky. Air toxics modeling was performed by the Division for Air Quality using the computer model ISC-PRIME and additional risk analyses were performed by the Division of Environmental Services.

<u>Criteria Air Pollutant Modeling</u>

U.S. EPA provided CMAQ modeling results to Kentucky for the 1-hour and 8-hour ozone standards, particulate matter, and visibility. The potential impacts on the carbon monoxide, lead, sulfur dioxide, and nitrogen oxide levels were not analyzed since compliance with those standards is not an issue in Kentucky. Originally, U.S. EPA also planned to provide information on acid deposition. However, not enough data was available to determine acid deposition contributions from the new power plants.

Due to the time constraints of the executive order, AMD used an existing emissions database previously used in the Southern Oxidant Study (SOS). EPA determined impacts on ozone, both the 1-hour and 8-hour standards, particulate matter, and visibility due to both existing and proposed power plants. AMD was able to adapt the on-going CMAQ modeling for the July 9-16, 1995, SOS episode to provide information tailored for Kentucky. The emissions and meteorological data used in this analysis were those for 1995 and were selected as the most readily useful. Plots of the data sets used are included in Appendix A. It should also be noted that this modeling episode (data set), while used in the SOS is also used in several regional air quality analyses that have been or are being performed.

When performing modeling for both ozone and fine particulate matter, a complex interaction among many sources, including the source of the study's focus, must be considered. Both ozone and fine particulate are formed in the atmosphere from chemical reactions caused by the emission of many different pollutants. Ozone is formed when VOCs and NO_x interact in the atmosphere on hot, humid days when wind patterns are fairly stagnant. Ozone modeling is performed using a summer scenario due to the role of heat and sunlight in ozone formation.

In performing the modeling, Kentucky also used “worst case scenarios” which utilized historic 1995 emissions for Kentucky and added the potential emissions from the new power plants. It is almost certain that some emission levels have changed since 1995, but use of the data set was conservative and appropriate.

The modeling also does not consider additional emission changes due to the implementation of several national and regional emission reduction programs slated to begin by 2004. Most states east of the Mississippi River, including Kentucky, have federal mandates to reduce NOx emissions, primarily from power plants, by 2004. Utilities will have the option of reducing their emissions or buying emission allowances from other utilities (throughout the region) in order to meet those requirements. Not all power plants have made a decision on how they will meet those requirements. Therefore, this modeling exercise provided a conservative scenario designed to provide the greatest potential impacts from these new emissions if conditions in Kentucky remained the same. It is understood that NOx emissions will be decreasing over the entire region by 2004 and those impacts have not been included in this study.

The following table show the emissions used in U.S. EPA’s modeling in tons per summer day for the base model runs.

1995 Air Emissions
(*tons per summer day*)

Emission Category	CO	NOx	VOC	PM10	PM2.5	SO2	NH_4
Point Sources	289	1,250	371	97	36	2,377	3
Mobile Sources	2,641	375	364	15	12	15	13
Area Sources*	1,179	582	575	764	202	250	237
Biogenic		103	7,259				
Totals	4,109	2,310	8,569	876	250	2,642	253

**For purposes of this study, area sources include non-highway emissions.*

U.S. EPA then revised the inventory to add the proposed emissions from the new electric generating units in Kentucky. The following table outlines those additions.

Projected New Power Plant Emissions (by county)
(tons per summer day)

County	CO	NOx	VOC	PM10	SO2
Breckinridge	0.41	0.65	0.10	0.14	
Campbell	0.45	0.27	0.22	0.12	
Clark	5.35	13.31	0.95	1.06	10.77
Estill	2.50	1.02	0.13	0.17	1.73
Henderson	18.29	14.86	0.44	2.47	14.26
Jefferson	0.01	0.13			
Kenton	0.67	0.36	0.20	0.12	0.02
Knott	16.54	4.30	0.44	0.92	7.96
Lawrence	0.67	0.68	0.09	0.05	0.02
Marshall	20.18	6.95	0.85	1.68	8.16
Martin	16.54	4.30	0.44	0.92	7.96
Mason	4.50	3.00	0.11	0.90	6.00
Metcalfe	1.44	1.12	0.05	0.05	0.02
Muhlenberg	18.08	16.52	1.39	3.61	30.01
Oldham	0.67	0.26	0.05	0.05	0.02
Trimble	10.68	6.12	0.70	1.29	0.09
Totals	117	74	6	14	87

Of particular note in this modeling study is the impact pattern. For most days throughout the July 9-16 episode, the majority of impacts from adding emissions for new electric generating units occur in the western part of the state, close to where new power plants are being proposed. Impacts from removing all emissions for existing power plants are generally seen on a broad scale throughout the state.

Ozone

Ozone is not emitted; it is formed in the atmosphere. At ground level, ozone is a respiratory irritant. At even fairly low levels it can affect people with existing respiratory and pulmonary problems such as asthma, emphysema, bronchitis, and other health disorders. At slightly higher levels, people who typically work outdoors a significant part of the day, and children who are outside a great deal during the summer months, are affected. At higher levels, even healthy individuals have health effects from ozone. Several areas in Kentucky have historically had problems meeting the 1-hour ozone standard and now a new, more stringent standard is on the horizon to help protect those individuals most susceptible to ozone effects.

Ozone is a warm weather pollutant. Emissions of VOCs and NOx, when mixed with high heat, humidity, and stagnant air patterns, help to create ozone. The unique chemistry involved in ozone formation provides reactions that are not linear in nature. Adding an additional amount of NO_x or VOC emissions to a mix does not give an equivalent increase in ozone formation. The same can be said with emission decreases. If emissions are decreased by a certain percentage or amount, a like ozone reduction is not obtained.

A review of actual ozone monitoring data for the period used in the air quality modeling (July 9-16, 1995) shows that exceedances of both the 1-hour and 8-hour ozone standard occurred in Kentucky during that period. That exceedances actually occurred during this time shows that ozone formation was taking place at levels that would exceed one or both of the ozone standards. That makes the data set a valid episode to be used in analyzing potential emission increase impacts on ozone formation.

***1-Hour Ozone Standard* -** Ozone is monitored on a continuous basis from March 1 through October 31 of each year. For the 1-hour standard, the highest value for a one-hour period is recorded as the hourly value. For each day, 24-hourly ozone levels are provided. The highest of the 24 for that day is considered the level for that date. The 1-hour ozone standard is set at 0.12 ppm and is a three-year standard. That means three exceedances of the standard are allowed in three years. If four exceedances occur in a three-year period, air quality at that monitoring site is considered "in violation."

One exceedance of the 1-hour standard occurred in Jefferson County during the July 9-16, 1995, timeframe. Another four exceedances of the 1-hour standard occurred in the Cincinnati/Northern Kentucky area, and one additional exceedance occurred in the Huntington/Ashland area. While it is important to maintain the standard in all areas, the following areas in Kentucky have, at some time, been in violation of the 1-hour ozone standard and have been subsequently re-designated to attainment. All areas of the state are attaining the 1-hour ozone standard at this time.

Re-designation Dates for
1-Hour Ozone Attainment

Area	Re-designation Date
Daviess County & a portion of Hancock County	January 3, 1995
Edmonson County	January 3, 1995
Marshall & a portion of Livingston County	April 10, 1995
Boyd & a portion of Greenup County	June 29, 1995
Fayette & Scott Counties	November 1995
Jefferson & portions of Bullitt & Oldham Counties	November 23, 2001*
Boone, Campbell & Kenton Counties	July 5, 2000**

**U.S. EPA has proposed re-designation to be effective on that date*
*** U.S. EPA had re-designated on that date, U.S. 6th Circuit overturned EPA's designation based on procedural issues on the part of Ohio on September 11, 2001. Area continues to maintain standard. EPA to take action in future to designate back to attainment.*

Projected emissions from the new electric generating units are anticipated to add an additional 74 tons per day of NO_x. Based on the modeling performed by U.S. EPA, adding the new power plant emissions to those already in existence may increase anticipated daily 1-hour ozone levels 0.006 ppm to 0.014 ppm in areas downwind of the new plants. This range represents a 6.25 percent to 13.33 percent increase in anticipated 1-hour ozone levels. The greatest impacts in the simulation occurred on July 14 & 15, 1995, where the differences of 0.012 ppm and 0.014 ppm, respectively, were projected in grid cells in Western Kentucky. Coupled with projected reductions in 1-hour ozone readings resulting from implementation of the NO_x SIP Call, 1-hour ozone values throughout the state should remain below the 0.12 ppm standard after all of the 22 new power plants are in operation.

In 1995, existing electric generating units emitted 1,155 tons of NO_x per day. This represents 50 percent of the total NO_x emissions in the state. The second round of modeling performed by U.S. EPA, where all emissions for existing electric generating units were removed, showed a wide range of impacts. Maximum decreases in ozone concentration range from 0.039 ppm to 0.089 ppm. These figures represent approximate reductions of up to 59 percent in ozone formation in individual grid cells where the maximum concentration differences were modeled each day. A region-wide reduction at those levels does not occur. However, decreases in ozone concentrations ranging from 0.003 ppm to 0.024 ppm were modeled in broad areas of the state during the modeling episode. Eliminating existing unit emissions actually causes a slight increase in 1-hour ozone levels in some urban areas on various days throughout the period.

8-Hour Ozone Standard - The 8-hour ozone standard, adopted by U.S. EPA in 1997 is set at 0.08 ppm. Like the 1-hour ozone standard, the 8-hour standard is a three-year standard. However, unlike the 1-hour ozone standard, which looks at the single highest 1-hour value, the 8-hour standard is based on the average highest 8-hour readings for a day. The fourth highest 8-hour average is used for each of three consecutive years and averaged. If the average is over the standard, the area is considered to be in violation. This standard has been challenged in court. Several business organizations, industries, and states sued U.S. EPA over the established level, the proposed implementation of the standard, and the agency's right to set the standard. The U.S. Supreme Court has ruled that U.S. EPA has the constitutional authority to set the standard, but it did not agree with the implementation methodology set by U.S. EPA. The Washington, D.C., Circuit Court is also expected to hear arguments in December 2001, on the standard and whether U.S. EPA adequately considered beneficial health impacts that ozone may have. Until these court challenges are resolved and U.S. EPA has completed rulemaking and adopted a new implementation strategy, designations of areas that meet or do not meet the 8-hour standard will not be established. U.S. EPA is projecting that it may be 2004 before designations are made under the 8-hour ozone standard.

However, states are under obligation from the 1990 Clean Air Act Amendments to submit information on air monitoring results in response to the 8-hour standard. In June 2000, Kentucky submitted a list to U.S. EPA of counties that had the potential to be designated as not meeting the 8-hour ozone standard. This list was based on 1997-1999 air monitoring data. Monitoring data for 1999-2001, indicate that the list should be revised. In addition, monitoring data for each of these areas may change. There are some areas of the state that would be designated as non-attainment for the 8-hour ozone standard if designations were made now. Counties other than those included in the following list may be designated as non-attainment if they have emissions that impact the listed counties.

Counties with ozone monitoring data in violation of the 8-hour ozone standard
(1999-2001 Air Monitoring Data)

Boone	Boyd	Bullitt	Campbell
Christian	Edmonson	Greenup	Jefferson
Kenton	Livingston	McLean	Oldham
Pulaski	Simpson		

Based on the modeling performed by U.S. EPA, adding the new power plant emissions to those already in existence may increase anticipated daily 8-hour ozone formations from 0.003 ppm to 0.011 ppm in areas downwind of the new units. This range represents a 3.75 percent to 11 percent increase in anticipated 8-hour ozone levels. The greatest impacts in the simulation occurred in the July 14 & 15, 1995 data sets where differences of 0.011 ppm were projected in Western Kentucky.

Even coupled with the expected benefits from the NO_x SIP Call, the model shows that additional emissions from new electric units could impact 8-hour ozone values in various parts of the state. Some areas may even fail to meet the 8-hour standard. Modeling indicates that this is particularly true in the Lawrence/Boyd County area and the Daviess/Henderson County area from additional emissions associated with the Dynegy Riverside facility in Lawrence County and the Grane and Cash Creek facilities in Henderson County. Conversely, in a few instances, increasing NO_x emissions actually decreased ozone formation to a slight degree, in specific small areas.

The second round of modeling for the 8-hour standard, where all emissions for existing electric generating units were removed, showed a wide range of impacts. The overall effect was that existing power plant emissions appear to have a greater impact on a wider scale than the emissions from the new plants. This is to be expected since the total amount of emissions from the existing electric generating units is much larger than the total amount from the new units. A decrease in ozone formation from 0.021 ppm to 0.056 ppm was seen in Kentucky during this model run. These figures represent approximate reductions of up to 50 percent in ozone formation at specific grid cells where the maximum concentration differences were modeled each day. The maximum decrease in Kentucky occurred in the July 15 data set, toward the end of the episode, in Western Kentucky. A region-wide reduction at those levels does not occur. However, ozone concentration reductions were projected to occur over a more regional/state scale each day of the period.

There were some instances of "disbenefit" in areas. This means that in some instances, zeroing out all power plant emissions in the state actually resulted in an increase in projected ozone concentrations, generally in urban areas.

Fine Particulate Matter

Fine particulate matter, like ozone, is typically not emitted, but forms from other compounds such as nitrates and sulfates emitted into the atmosphere. Particulate matter has been regulated since the 1970s. Early standards were established for welfare-related effects. The standard was set for particles that were unlikely to be inhaled. In the mid-1980s, U.S. EPA developed a PM_{10} standard. This established a concentration limit for particulate matter ten microns in size that is small enough to be inhaled into the respiratory system. In 1997, U.S. EPA developed the fine particulate standard after health studies showed that it was the very fine particulate ($PM_{2.5}$) that was inhaled deep into the lungs and respiratory system and caused the most damage.

Fine particulate matter has two standards; a 24-hour standard set at 65 micrograms per cubic meter (ug/m3), and an annual standard set at 15 ug/m3. These standards did not exist in 1995, during the episode modeled, so no historic monitoring data exists for comparison. However, a comparison can be made to recent fine particulate emission. Based on recent monitoring reports, Kentucky has no areas out of compliance with the 24-hour fine particulate standard, but has several areas that could fall out of compliance with the annual standard. Sampling is proceeding to determine what types of particles are contributing to the high fine particulate samples and where those emissions may originate. This will be completed before Kentucky proposes any plans in response to this standard.

The U.S. EPA performed modeling for fine particulate and for sulfates, which are a subset of fine particulates. For fine particulate, hourly average concentrations and changes in those concentrations were determined for adding potential power plant emissions and removing existing power plant emissions from the model.

Due to the short timeframe for completing the modeling exercise, U.S. EPA was unable to perform the routine base simulation model evaluations and was only able to perform limited quality assurance on the output runs. However, there is a high degree of confidence for the results within Kentucky's boundaries.

New electric generating units contribute fewer emissions that form fine particles than existing power plants. Projected SO_2 emissions from proposed new power plants are anticipated to be approximately 87 tons per summer day. The U.S. EPA model projects the additional emissions from the new electric generating units will contribute insignificant amounts in limited areas throughout the state. Impacts of up to 1.144 ug/m3 for an hourly average are seen in the modeling. These impacts mostly occur in areas where the new units are proposed.

The second round of modeling performed by U.S. EPA for the fine particulate standard, where emissions from existing electric generating units were removed, showed a wide range of impacts. In general, existing coal burning electric generating units play a significant role in fine particulate formation. Existing units generate approximately 2,264 tons of SO_2 per summer day. In Kentucky, maximum contributions of up to 23.75 ug/m3 for an hourly average were modeled. However, some degree of impact is seen on a wider state scale for each day of the modeling analysis.

The separate modeling performed for sulfates, mirrors the results of those found for total fine particulate. Modeled increases are seen in very limited areas with a range from 0.284 ug/m3 through 1.0 ug/m3.

<u>Visibility</u>

In our nation's scenic areas, the visual range has been substantially reduced by air pollution. In eastern parks, average visual range has decreased from 90 miles to 15-25 miles. Typically, in Kentucky, sulfates and to some extent nitrates, are major contributors to the decline in visibility.

While there is no one definition of visibility that meets all the criteria of "seeing" landscape features, a number of visibility indices have evolved. Gauging whether visibility is getting better or worse is sometimes expressed in terms of "deciviews." Deciviews represent the improvement/worsening of visibility. For example, visibility up to 130 kilometers is equivalent to 11 deciviews. Increasing deciviews to 14 decreases visual range down to 100 kilometers.

U.S. EPA's modeling shows what would be considered base visibility, gauged in deciviews and attempts to show a change (in deciviews) when emissions are added or taken away. The results from this modeling exercise are inconclusive and this model does not appear to be an appropriate tool for purposes of determining visibility impacts for this study.

A more accurate representation of whether proposed facilities may impact visibility can be accomplished using the CALPUFF model recommended by U.S. EPA and the Federal Land Managers. Some power plant permit applicants have used this model with results showing impact to Class I areas like Mammoth Cave and the Great Smoky Mountains. Time and resource constraints prevented a thorough, combined analysis where more than one of these facilities is proposed to locate. However, very large emitting sources are required to provide the analysis to the Cabinet on a case by case basis. Additional controls have been required at facilities where substantial impacts were projected to occur.

Hazardous Air Pollutants

Hazardous air pollutant emissions were also evaluated to determine the potential environmental impacts caused by new emissions. Hazardous air pollutants, also known as air toxics, are chemicals that can cause serious health and environmental problems. To perform this analysis, the Division for Air Quality worked in conjunction with the Division of Environmental Services to determine if modeled emission levels produce an unacceptable risk level for citizens in the Commonwealth. Details associated with this study can be found in Appendix B of this document.

Air toxics typically associated with power plant emissions were compiled to identify the pollutants that were likely to be emitted by both the proposed new and expanding power plants and the existing plants. These compounds were evaluated using risk-screening values and projected emission rates to determine which toxics would be included in the air toxics modeling project. Through this process the Cabinet identified 13 hazardous air pollutants that warranted specific evaluation. These pollutants are listed in the following table:

Hazardous Air Pollutants Included in the Air Toxics Modeling Assessment

Arsenic	Benzene	Dioxins
Formaldeyde	Lead (tetraethyl)	Mercury
Nickel	Hydrogen Chloride	Benzo(a)Pyrene
Cadmium & compounds	Chloroform	Beryllium & compounds
	Total chromium	

Due to time constraints, the Cabinet was unable to model every existing and proposed power plant in Kentucky. To address this limitation, an analysis was performed to determine similarities between the plants. If multiple plants were alike in design and operation, then in some cases, a representative plant was selected. The power plants that were modeled were selected based on their size, location, fuel source, and proximity to other power plants.

Proposed EGUs Modeled for Hazardous Air Pollutants

Proposed EGU	*Size (MW)*	*Fuel*	*County*
Kentucky Western Pwr	500	Waste Coal	Marshall
Kentucky Eastern Pwr	500	Waste Coal	Martin
Kentucky Mt. Pwr	500	Waste Coal	Knott
Thoroughbred	1,500	Coal	Muhlenberg
Cash Creek	1000	Coal	Henderson
Dynegy-Riverside	1,040	Natural Gas	Lawrence
Global/Pioneer	540	Coal/ Garbage	Clark
J.K. Smith	400	Natural Gas	Clark
Duke Energy	640	Natural Gas/Oil	Marshall

Existing EGUs Modeled for Hazardous Air Pollutants

Existing EGU	*Size (MW)*	*Fuel*	*County*
Green Station	484	Coal	Webster
Reid/Henderson	450	Coal	Webster, Henderson
Green River	265	Coal	Muhlenburg
Wilson Station	440	Coal	Ohio
TVA Paradise	2,558	Coal	Muhlenburg
Big Sandy	1,096	Coal	Lawrence

Some of the existing power plants and proposed new or expanding power plants are located close to each other. Individually, these plants may not produce pollutants at a level for concern; however, collective emissions may present a problem. To account for this scenario, five power plant clusters were identified and modeled as groups. These clusters consist of new and existing plants. They were chosen based on their proximity to each other or proximity to large population centers. Of particular concern with some of the clusters was the significant increase in NOx emissions in areas with historic ozone problems. In addition, some cluster areas were projected to have problems meeting the new fine particulate standard. The Marshall County Cluster includes several facilities with significant emissions and is in close proximity to the Paducah area. The Central Cluster was modeled due to its close proximity to the Lexington/Fayette County area. The Muhlenburg Cluster includes both the TVA-Paradise plant, which has been a high emission facility, and three proposed facilities within the same county. The Henderson County Cluster is again an area with historic problems meeting the ozone standard(s) and had significant emissions within the Evansville/Henderson multi-state urban area. The clusters are:

Marshall County Cluster Kentucky Western Power Enron Duke Energy Westlake	**Muhlenburg County Cluster** Green River Wilson Station TVA Paradise Thoroughbred
Henderson County Cluster Grane Creek Cash Creek Green Station Reid/Henderson Station	**Central Cluster** Global Pioneer Energy JK Smith
Eastern Kentucky Cluster Dynegy-Riverside Big Sandy-Louisa	

Based on the dispersion modeling output, there are four chemicals that exceeded their risk-based screening value for human inhalation exposure. All four of these pollutants are carcinogens. The four chemicals that exceeded their screening values were arsenic, beryllium, total chromium, and nickel. This means that the model indicates these chemicals may occur at a level of concern. The clusters and plants predicted to have significant ambient impact by emitting hazardous air pollutants are as follows:

Locations with Air Toxics Impacts

Henderson County Cluster	(Arsenic, Total Chromium)
Global Pioneer/J.K. Smith	(Arsenic, Nickel)
Eastern Kentucky Power	(Total Chromium)
Duke Energy	(Nickel, Total Chromium)
Muhlenberg County Cluster	(Arsenic, Beryllium and compounds, Total Chromium)

The chemical found at the highest level of concern was total chromium. The model predicted that the existing Reid/Green/ Henderson complex releases this chemical at greater than 50 times the screening value.

There were four additional chemicals that did not exceed the screening level, but their levels were high enough to warrant additional attention. These chemicals were benzo(a)pyrene, cadmium, formaldehyde, and hydrogen chloride. Even though these chemicals may be at safe levels when evaluated individually, collectively they may contribute to the total risk from the facility, particularly when several chemicals act on the same organ system.

Acid Deposition

Originally, U.S. EPA had planned to provide Kentucky with information on potential acid deposition impacts from the proposed power plants. However, the CMAQ model would require a much greater time period data set than was available to provide meaningful results. A much longer time period to conduct the study and substantial funds would also be necessary in order to garner potential impacts on acid deposition from the proposed power plants in Kentucky. U.S. EPA has estimated that an entire year of monitoring data would have to be incorporated into the modeling and meteorological files in order to project meaningful potential impacts. It is unclear what the final cost for this process would be, and how much of an impact the NOx SIP Call reductions would have in the meantime.

However, it should be noted that nitrogen oxides and sulfates both play a role in forming acid deposition. Therefore, increases in these pollutants would theoretically increase the potential to form acid deposition.

Water Quality Impacts

A combination of state and federal laws are applicable to the protection of water resources, water quality and drinking water. The Clean Water Act and the Safe Drinking Water Act are the primary federal laws that establish the minimum standards for water resource protection. Many of Kentucky's industries, including power plants, are regulated within these laws.

Power plants have the ability to impact Kentucky's water resources in multiple ways. Steam producing power plants often require a significant amount of water as part of their operations. Removing large amounts of water without proper management can result in undesirable environmental impacts. Water resources can also be affected by power plant wastewater discharges. As a result, power plants are required to ensure that their wastewater discharges are in compliance with permit limitations designed to protect water quality. A third type of potential water quality impact is groundwater contamination. Many people depend on groundwater resources for their personal water supply. Improper waste management by power plants can lead to contaminated groundwater. All of these potential problems can pose a risk to Kentucky's citizens as well as to the environment.

Water Withdrawal

Many of the electric generating power plants in Kentucky require a significant supply of water. The water is withdrawn from a nearby water body (river, lake or groundwater) and is used to feed boilers, cool process water, clean equipment, and transport ash to on-site sanitary facilities. Each day, it is estimated that the existing baseload generating plants in Kentucky withdraw more than three billion gallons of water from Kentucky streams. Power plants that only operate during hours of peak electricity demand use considerably less water. These peaking plants will use water only when they are in operation. Natural gas turbine plants will often not use water in their processes at all. Natural gas plants that do use water in their processes vary in the amount of water that they use. However, when compared to coal-fired plants, natural gas plants use a significantly lower amount of water. Also, since plants that burn natural gas will not produce ash, natural gas plants will not require water to transport waste products.

The Commonwealth has adopted a water withdrawal permitting program to keep track and reconcile all of the previously mentioned water uses. This program is authorized under KRS 151.140 and administered by the Water Resources Branch of the Division of Water. All withdrawals of water are subject to this permitting program unless it falls under one of three exemptions. These exemptions are for withdrawals of less than 10,000 gallons per day (gal/day), withdrawals for steam electric generating plants regulated by the PSC, and withdrawals for agricultural uses. Based on these criteria, all existing power plants are currently exempt from water withdrawal permitting requirements. Withdrawals from groundwater are not exempt and all groundwater applications are routed through the Division of Water's Groundwater Branch.

Because many of Kentucky's power plants are exempt from water withdrawal requirements, the Cabinet does not have an accurate inventory of the volume of water being removed each day by the existing power plants. In addition, the Cabinet has not yet received a comprehensive inventory of the anticipated water withdrawals that will be conducted by the new or expanding power plants. Therefore, it was not possible for the Cabinet to conduct a thorough quantitative evaluation of water withdrawal impacts in this report for either the existing or the proposed new and expanding plants. In spite of these limitations, some assumptions can be made concerning the potential impacts caused by power plant water withdrawal.

The greatest water use in the existing plants occurs when water is converted to steam and then passed under pressure through turbines to convert its energy into electricity. Some plants recycle much of this water by using it as many times as possible before discharging most of it back to the stream. The plants that withdraw the greatest amount of water are those that do not recycle the water in their processes and discharge it back into the stream after only one use. Water is also used within the electricity generating process in ways other than for the production of steam for turbines. In the process it sometimes is mixed with lime and used in sulfur removal from exhaust gases; water is also used, at times, to clean air pre-heaters. Coal, after crushing and prior to combustion can be mixed with water and transported in pipelines or tankers. In some coal burning plants, water is used to sluice the ash and to transport and dispose of this in ash settling ponds. Not all of the water withdrawn by existing power plants is returned to the water body from which it was removed. A large amount of water is often lost when water is released as steam into the air through the power plant's cooling towers and not returned to a stream system.

The amount of water that is converted to steam in the cooling process is somewhat dependent upon the ambient air temperature and the plant's electric generation process. In addition to water lost as steam, water used to transport ash to settling ponds may also be lost if it is not returned to its originating stream. The following table illustrates the diversity in the percentage of water consumed by power plants.

Percentage of Water Consumed at Existing Power Plants

County	Water Withdrawn (MGD)	Percent Consumed
McCracken	981.12	0%
Jefferson	705.04	2%
Muhlenberg	482.74	8%
Pulaski	383.06	2%
Hancock	225.01	0%
Daviess	196.51	0%
Webster	148.9	32%
Henderson	105.45	33%
Clark	103	1%
Mason	38.22	19%
Carroll	25.79	85%
Mercer	17.19	73%
Woodford	13.19	0%
Lawrence	6.85	100%
Boone	6.85	79%
Ohio	4.72	92%
Bell	0.28	25%

Source: 1995 USGS Water Use Survey

The removal of extremely large quantities of water from the stream can potentially have a bearing on water availability for other commercial and public uses, particularly in the summer peak-generating season that often coincides with low flow in streams. This removal of water can also impact the aquatic life in a stream. Potential ecological impacts associated with water removal include entrainment (the death of fish and other aquatic animals caught in the water intake) and a reduction in instream habitat during times of low stream flow during peak electricity production times. The reduction of water available to a stream can ultimately lead to the modification or destruction of fish and invertebrate habitats.

Hydroelectric plants also have an impact on stream systems even though the water is only diverted, not completely removed from the water system. The same intake and flow impacts, entrainment, and habitat reduction are present as for the fuel burning plants. Dam construction can permanently alter the flow regime and aquatic habitat. However, water held and released from impoundments during high and low flow times can also provide a positive result for the maintenance of flow for the protection of other downstream uses.

When issuing permits for water withdrawal, the Division of Water's Water Resources Branch may allocate up to 10 percent of a stream's lowest average monthly flow. This is done to ensure that sufficient flow is reserved for allocation to future users, to maintain water quality and stream habitat, and to ensure that other public interests are protected.

Another way that the Water Resource Branch evaluates water withdrawal permit applications is by using the 7Q10 flow for that stream. The 7Q10 flow refers to the lowest historic flow to occur for a 7-day period once every 10 years. This is used by water quality agencies nationwide. In streams where the 7Q10 flow is greater than zero cubic feet per second, or where multiple users are located in the same stream reach, restrictions may be placed on withdrawals during periods of abnormally low flow. The nature of these restrictions, triggered when a stream reaches 7Q10 flow, can range from a complete cessation of withdrawals on smaller, unregulated streams, to pre-defined withdrawal reduction schedules on regulated streams.

As mentioned previously, all of the existing power plants located in Kentucky are exempt from water withdrawal permitting requirements. However, if they were required to obtain a water withdrawal permit, four of the existing plants currently withdraw water from a stream at rates greater than 10 percent of the stream's harmonic mean, a measure that is generally not as conservative as the monthly average low flow. These plants are the Dale, Green River, Tyrone and Paradise facilities. Based on these assumptions, if they were not exempt from permitting requirements, at least these four plants would not likely be issued a water withdrawal permit for the current rate of withdrawal without permit restrictions that ensure adequate water remains in the stream to protect aquatic systems and water supply needs.

Water Withdrawal at Existing Power Plants

Plant	Water Source	Intake Flow, MGD	Stream Flow*, MGD	Intake as % of Stream Flow
East Bend	Ohio R.	19.5	37,046	0.05
Cooper	Cumberland R.	383.0	N/A (Lake)	N/A
Dale	Kentucky R.	109.0	593	18.4**
Spurlock	Ohio R.	7.2	32,690	0.02
Smith	Kentucky R.	0.3	565	0.05
Henderson 1	Ohio R.	20.4	50,388	0.04
Big Sandy	Big Sandy R.	19.4	1,057	1.8
Brown	Herrington Lake	18.4	N/A	N/A
Ghent	Ohio R.	71.1	35,660	0.20
Green R.	Green R.	283.0	2,509	11.3
Pineville	Cumberland R.	0.1	125	0.03
Tyrone	Kentucky R.	184.1	667	27.6
Cane Run	Ohio R.	373.0	37,080	1.00
Mill Creek	Ohio R.	270.0	37,080	0.73
Ohio Falls	Ohio R.	5.0	37,080	0.01
Paddy's Run	Ohio R.	1.5	37,080	.004
Trimble Co.	Ohio R.	9.2	37,080	0.02
Smith	Ohio R.	216.0	41,990	0.51
Paradise	Green R.	359.0	2,450	14.6
Shawnee	Ohio R.	1,177.0	11,3050	1.04
Coleman	Ohio R.	280.0	41,667	0.67
Reid/Green	Green R.	81.0	3,295	2.46
Wilson	Green R.	6.1	2,515	0.24

*Harmonic Mean
**Regulated Pool

Water withdrawals made by the proposed new and expanding fuel-burning power plants can potentially affect water resources in the same ways as the existing plants. An adequate and consistent supply of water will be required for nearly all of the newly proposed plants and will be one of the primary considerations when choosing a location.

It is anticipated that the proposed baseload coal burning and waste burning facilities will use large amounts of process water. Newer technology allows water to be extensively recycled within the generation process. This should help reduce the amount of water needed. In addition, newer methods are available to transport and dispose of ash. Therefore, newer plants may use less water than some existing baseload plants currently require. However, the information that has been supplied to the Cabinet by some of these proposed plants indicate that, on average, the expected withdrawals for each of the proposed baseload plant is still expected to be greater than seven million gallons per day.

New power plants that only operate during hours of peak electricity demand will use considerably less water and their water withdrawal impacts are not expected to be as significant, except during times of low stream flow. These peaking plants will use water only when they are in operation. It is possible that some of the natural gas turbine plants will not use water in their processes at all. Also, since plants that burn natural gas will not produce ash, natural gas plants will not require water to transport waste products.

Surface Water Discharges

The Clean Water Act requires the Commonwealth to set Water Quality Standards (WQS) and to administer a discharge permitting program. In Kentucky, this permitting program is called the Kentucky Pollutant Discharge Elimination System (KPDES). Facilities that release water to a stream via an outfall are required to obtain a permit from the Division of Water's KPDES Branch.

The water that is discharged from a generating facility can be derived from several sources. Process water makes up most of the wastewater discharged by existing power plants. Process water can contain concentrations of suspended solids or inorganic salts, as well as a thermal load. Process water may also contain metal cleaning wastes, which include copper and iron. The effluents from ash ponds also make up a portion of water released by many existing plants. In some plants, sanitary wastewater discharges occur. Often sanitary wastewater, as well as the blow down water from the boiler, is sent to the ash pond before final discharge. Finally, runoff from rainfall events, including stormwater that is collected from around the coal storage piles or other facility areas, is also part of the discharged effluent.

The issues of greatest environmental concern from the permitted water discharges of power plants are temperature increases caused by the process water, metals contamination, including mercury, Total Suspended Solids, oil and grease, and pH changes. Metals contamination can originate from the process water and from stormwater runoff originating from coal storage areas and other areas of the plant.

All regulated wastewater discharges must comply with the plant's KPDES permit. These permits indicate how much wastewater the plant can discharge and sets limits on how much pollution the discharge can contain. These limits are established to ensure that the stream receiving the discharge is safe to humans and the ecosystem. Not all pollutants found in power plant wastewater have discharge limits. For some chemicals, facilities are only required to monitor and report the amounts of these pollutants released to water. These monitor-only elements often include heavy metals such as arsenic, cadmium, copper, and mercury. Fly ash landfills and ponds are the predominant source of these chemicals. All permitted discharges are reported on Discharge Monitoring Reports (DMRs) and submitted routinely to the Division of Water.

The DMR from all of the existing plants were evaluated in conjunction with this report to estimate potential impacts of surface water outfalls. During the time period evaluated by this study, approximately two-thirds of the existing power plants reported a numeric permit violation. However, the actual number of violations per parameter per facility was quite low. The DMR reports were evaluated in two ways: do wastewater discharges from existing power plants pose an unacceptable risk to humans, and do these wastewater discharges pose an unacceptable impact to aquatic life?

In the human impacts risk analysis, more than one-half of the parameters in the undiluted outfalls exceeded risk-based residential tap water screening values. When the undiluted values were also screened against the Maximum Contaminant Levels (MCL), arsenic and copper exceeded the MCL (MCLs are standards set by the Drinking Water Program to ensure proper drinking water treatment at public water supplies). Both of these analyses indicate that water collected directly from the discharge point would not be safe to drink. The risk evaluation also indicated that the discharge would not be safe to humans exposed during recreation such as swimming. However, after the discharge was mixed with the receiving stream, there were very few exceedances of the risk-based numbers for recreational use of the water, and none of the parameters exceeded the MCL. U.S. EPA will be changing the MCL for arsenic from 50 micrograms per liter to 10 micrograms per liter. All water systems must be in compliance with this new standard by January 2006. When the power plant discharges are evaluated using this new standard, the discharges slightly exceed the new MCL even after the effluent is mixed with the receiving stream. This indicates that it is not safe to drink or contact water being discharged directly from power plants. After the water is mixed with the receiving stream, there may be a risk to humans from arsenic if they use that water for drinking without treatment. Exceedance of the MCL does not necessarily indicate poor stream quality. MCL standards are used to measure the quality of treated drinking water. Stream quality is measured using water quality standards. Arsenic is within its limits for the warm water aquatic habitat standard.

Surface water discharges with heavy metal contamination may impact aquatic organisms as well as accumulate in fish tissue. Predatory birds and mammals can also accumulate these toxins by consuming fish. The ecological assessment conducted as part of this study evaluated surface water discharges and the potential impacts to aquatic ecosystems. This study determined that six of the 12 plants that were evaluated had calculated exceedances of water quality standards for the Warm Water Aquatic Habitat use category. The pollutants identified as a problem included chromium, copper, lead, manganese, nickel, selenium, zinc, and iron. The ecological assessment also evaluated the results of toxicity testing required at nineteen of the existing power plants. Toxicity testing is used to monitor potential effects of the effluent on aquatic organisms. The results of these tests show that the majority of power plants seem to be operating acceptably most of the time. However, despite the fact that most of the toxicity tests showed acceptable results, excessive toxicity was reported at four plants. Additional discussion on wastewater toxicity can be found in Appendix E of this document.

Specific studies related to the proposed new or expanding power plants actual discharges could not be conducted. The Cabinet does not currently have adequate information describing the quantity and type of wastewater discharges that these plants will conduct. However, it is anticipated that the new and expanding power plants will face many of the same wastewater discharge issues posed by the existing plants. The Cabinet was able to evaluate whether the locations of the proposed power plants may impact existing drinking water treatment plants.

To identify potential contamination threats within the areas upstream of public water supplies Source Water Protection Plans (SWAPP) are used by various planning groups. Each SWAPP contains an inventory of these possible contamination sources broken down into three “zones." Zone 1 refers to an area reaching from ¼ mile below the water supply intake to a distance of five miles upstream. The selection of five miles was intended to be compatible with the Division of Water’s “Five Mile Policy” (a brief explanation of which is below). Zone 2 would inventory moderate and high hazards of contamination in the water supply starting at five miles and extending to 10 miles upstream (this corresponds to the distance most streams would cover in about one to five hours). Zone 3 then provides for a listing of water supply threats in the area 10 to 25 miles upstream of the intake or within 2½ to 12½ hours of stream travel.

Related to the SWAPP concept of protecting water supplies from contamination is the Division of Water’s “Five Mile Policy." The Five Mile Policy is incorporated by reference into Kentucky's environmental regulations at 401 KAR 5:005 Section 29 (2)(a). This policy prohibits new sources of wastewater within five miles upstream of a water treatment plant intake. The policy also prohibits new drinking water intakes within five miles downstream of known discharges of wastewater.

Proximity of Proposed Power Plants to Water Treatment Plants and SWAPP Zones.

Plant	Fuel Type	WTP Proximity
Dayton Power / Light	Nat. Gas/Oil Peaking	Not within 5 miles of any SWAPP
Trigen-Cinergy	Nat. Gas Peaking	Within 5 miles of Newport WTP and NKWSD WTP and in Zone 1 SWAPP for Newport WTP
EKP – J. K. Smith	Nat. Gas/Oil Peaking	Within Zone 3 SWAPP for Winchester WTP
Global Energy-Ky. Pioneer Energy	Gasified Coal/Garbage Baseload	Within Zone 3 SWAPP for Winchester WTP
Calla Energy	Waste Coal Baseload	Within Zone 3 of Richmond WTP
Cash Creek	Unknown	Not within 5 miles or any SWAPP
Columbia Electric-Grane Creek	Nat. Gas Peaking	Not within 5 miles or any SWAPP
LG&E Paddy's Run	Nat. Gas Peaking	Not within 5 miles or any SWAPP
Cinergy Energy Erlanger	Nat. Gas Peaking	Not within 5 miles or any SWAPP
Enviropower-Ky Mountain Power	Waste Coal Baseload	Within Zone 1 of Jackson WTP
Dynegy-Riverside	Nat. Gas Peaking	Not within 5 miles or any SWAPP
Air Products & Chemicals	Nat. Gas Cogen.	Not within 5 miles or any SWAPP
Duke Energy	Nat. Gas Peaking	Not within 5 miles or any SWAPP
Enron Calvert City Power	Nat. Gas Peaking	Not within 5 miles or any SWAPP
Westlake Energy	Nat. Gas Cogen.	Not within 5 miles or any SWAPP
Enviropower-Ky Eastern Power	Coal Baseload	Within Zone 3 of Martin Co. WD
Enviropower-Ky Western Power	Unknown	Not within 5 miles or any SWAPP
EKP - Spurlock	Coal Baseload	Not within 5 miles or any SWAPP
Duke Energy	Nat. Gas/Oil Peaking	Not within 5 miles or any SWAPP
Thoroughbred Generating	Coal Baseload	Within Zone 1 of Central City WTP
Dynegy Bluegrass	Nat. Gas Peaking	Not within 5 miles or any SWAPP
LG&E Trimble Sta.	Nat. Gas Peaking	Not within 5 miles or any SWAPP

As discussed earlier, the lower SWAPP Zone designations refer to closer and therefore more immediate threats from discharges or spills. Based on this analysis, the following proposed plants may deserve closer scrutiny during the environmental permitting process. The Trigen-Cinergy plant planned for Campbell County is within the Zone 1 SWAPP's of two drinking water treatment plants and within five miles upstream of one of them. Consequently, the new power plant will have to apply for a variance from the Five Mile Policy by demonstrating that their discharges will not pose any problems to the downstream intakes. Both drinking water plants will also have to identify any potential threats of contamination from the Trigen facility and formulate plans to counter these threats. This planning process may then feed back into the permitting process for the power plant and require, for example, the use of more foolproof or reliable spill containment measures. In like manner the Enviropower-Ky. Mountain Power and Thoroughbred Generating plants are within Zone 1 SWAPP's of the Jackson and Central City water treatment plants, respectively. Like the Trigen facility, this could lead to extra planning by the water treatment plants and extra discharge permit requirements on the generating plants.

Groundwater Contamination

The discussion related to water quality impacts has focused on surface water resources. There are also potential impacts to groundwater resources. Groundwater is a significant resource in Kentucky. Many of Kentucky's residents rely on groundwater as a private water source. Some public water supplies also acquire their source water from groundwater aquifers. In addition, approximately 50 percent of Kentucky is dominated by karst geology. Karst geology is characterized by limestone bedrock that has weathered to produce fractures and conduits, sometimes in the form of large caves. Karst geology makes groundwater protection challenging because groundwater contamination can spread quickly and in multiple directions.

Electric generating units that burn coal as a fuel produce a large amount of ash. Ash may be combined with limestone and other additives, such as ammonia, that are used to reduce sulfur emissions and ozone-producing gases, respectively. Ash disposal, if not properly managed, can have harmful effects on groundwater. Kentucky solid waste management laws require that all ash created at electric generation units must be beneficially reused or disposed of in an appropriate manner. Typically, this ash is discarded in either special waste landfills or in ash slurry impoundments. Nearly half of the existing power plants have a landfill located on the facility site. These landfills may also include partially combusted coal and other special wastes generated during coal production and washing. Special waste and residual solid waste landfills are not required to have a liner. However, the landfills are required to monitor groundwater for contamination. In addition to landfills, power plants may also manage their waste in ash ponds. Ponds that are used to hold the slurry and other waste from these facilities are not required to have a liner to prevent leaching.

Unlike special waste landfills, there are no requirements for groundwater monitoring around the ash ponds. It is possible for these landfills and ponds to release contaminants into the groundwater. Leachate from unlined ash and slurry ponds can seep into terrestrial and aquatic food webs through groundwater. Leachate susceptibility depends on factors such as soil type/permeability (sand and loam at highest risk) and mean annual rainfall (>30 inches at highest risk). Floodplain terraces composed of alluvial soils may be highly susceptible to groundwater contamination. Karst areas are also highly susceptible. Cabinet-issued floodplain permits showed that there are five existing facilities with fly ash landfills or ponds situated on river floodplains.

The Cabinet does not have enough data to determine if or to what extent groundwater contamination from ash ponds currently exists. However, the groundwater at one ash landfill was evaluated to assess potential impacts to groundwater. Groundwater monitoring results were compared to risk-based screening levels to determine if any groundwater contamination had occurred that would render the groundwater unsuitable as a drinking water source. The analysis results showed that arsenic and barium were above risk-based levels in the groundwater downgradient from the landfill. However, no groundwater contaminants were identified in concentrations greater than the MCLs. U.S. EPA will be changing the MCL for arsenic from 50 micrograms per liter to 10 micrograms per liter. All water systems must be in compliance with this new standard by January 2006. When the landfill monitoring reports are evaluated using this new standard, the discharges slightly exceed the new MCL. This indicates that there may be a risk to humans from arsenic if they use that water for drinking without adequate treatment.

The expected groundwater impacts from the proposed plants vary by type of plant and control technology used. Natural gas plants do not have the same groundwater issues as coal-fired plants. No ash is produced, therefore, slurry pond and landfill issues are not applicable. Coal-fired plants will have ash to discard. However, newer technology allows more complete combustion so it is possible that there will be a reduction in the amount of ash generated.

Land Quality Impacts

There are numerous considerations when evaluating impacts to the land resource from construction of power plants. The first impact is the preemption of the land and removal from other possible uses. The soil resource itself will be impacted for the life of the facility as well as after, due to the disposal of waste. Coal-burning facilities need an adequate supply of water, access to transportation for fuels, and adequate land for the storage of coal and the disposal of ash. Because of the need for adequate water, siting may be near major waterbodies. Prior to construction, evaluation of the site to minimize potential destruction of wetlands and riparian areas is necessary to protect both wildlife habitat and water quality. Also for fuel storage and waste disposal areas, the depth to seasonal high water tables, flooding hazards, and soil limitations for ponds and reservoirs must be evaluated to protect the facility and the surrounding area from the impacts of mishaps due to inappropriate siting.

Construction activities can impact floodplains by creating impervious surface areas, water diversion, and karst flow alteration. The land preparation for construction can lead to soil erosion and increase of sedimentation. The causes of run-off from the site and its storage piles must be considered in order to reduce impacts caused by erosion.

Landfill Creation and Operation

Ash disposal from coal-fired facilities is the primary environmental issue related to land use and power plants. The two primary environmental issues with ash disposal are (1) the amount of land that is used to dispose of this material and (2) the potential to leach contaminants, primarily metals, to surface water and groundwater from unlined landfills and settling basins. According to Division of Waste Management records, 16 ash landfills are currently permitted for disposal of ash from existing power plants. These permitted landfills total 6,062 acres. Approximately one acre of landfill space is required to dispose 100,000 tons of ash. These landfills typically range in size from approximately 40 acres to over 200 acres per facility. However, only a small portion of the permitted area is actually constructed and operating, and much of the permitted area may never be constructed. Based on the current volume of ash being discarded in landfills, and assuming an average fill depth of 60 feet, approximately 50 acres are filled each year. At this rate, 1,000 acres of permitted area will accommodate the existing volume of ash being landfilled for the next 20 years. In addition to the landfills on-site at the existing facilities, there are four off-site landfills that accept utility waste. At least one of these landfills was developed to accommodate a haul back agreement established with the state of Florida. Because of this agreement, all of the ash from coal mined in Kentucky and burned in Florida is returned to Kentucky for ultimate disposal. At least one additional facility takes ash from out of state power plants. The three new or proposed waste coal burning facilities will significantly increase the amount of ash requiring landfill disposal. These three plants will landfill approximately nine million tons of ash per year, compared to five million tons per year currently landfilled by the existing power plants. Approximately 90 acres of additional landfill space will be used each year to accommodate this waste.

While ash characteristics vary by plant and coal source, ash in general may be detrimental to the environment if improperly placed on the land. Land disposal may contribute to loss of habitat and may affect reproduction and development of a variety of organisms from aquatic invertebrates to predatory birds. Structural fills may be beneficial to humans by allowing development on land that was otherwise unsuitable, but, if improperly placed and compacted, the resulting fill could be unstable, or could leach excessively compared to appropriately engineered, well-compacted, and properly drained fills.

Kentucky regulations allow structural fill and other beneficial reuses of ash with very little oversight and few limitations. The generator of the ash does not need a written permit to conduct beneficial reuses. The generator is required to submit an annual report indicating the amount of ash beneficially reused, and the name and address of the recipient, but the specific reuse is required to be reported only “if known."

The Cabinet has identified a concern that some large-scale structural fills are not unlike landfills in many respects. However, an ash landfill owner or operator must obtain a permit. The permit application process requires engineering design details and hydrogeologic characterization of the fill site. The landfill design must include a groundwater monitoring system, and may require a compacted, low permeability soil or other type of liner. The Cabinet routinely inspects ash landfills and reviews groundwater monitoring data. Groundwater monitoring results have indicated leaching of contaminants at some landfills, suggesting concern that some ash structural fills may be having similar impacts. Lacking site-specific information and groundwater quality data, the cabinet is unable to evaluate these structural fills in terms of environmental or human health impacts.

It should also be noted that there is an artificial dichotomy in existing waste regulations. Special wastes are defined by statute to include fly ash, bottom ash and scrubber sludge generated by utilities. To be considered a utility, an electric power generating plant must be regulated by the PSC. Many of the proposed plants are merchant plants, and will not be regulated by the PSC. Ash generated at these facilities does not meet the definition of “special” waste, and will instead be regulated as solid waste. As such, the landfill permitting requirements will be more stringent than for publicly regulated utilities, while the beneficial reuse requirements will be less stringent. This may provide incentive for merchant plants to favor beneficial reuse options over landfill disposal. While this is consistent with the Cabinet’s statutory mandate to promote beneficial reuse, there is legitimate concern that a proliferation of marginally regulated ash structural fills could be detrimental to the environment.

Acid Deposition

It has been well documented that atmospheric deposition of acid-forming compounds have altered terrestrial and aquatic communities in various regions around the globe (Dillon et al. 1984). Acid deposition affects the environment in several different ways. In terrestrial plant communities, the impact of acid deposition is dependent on the type of soil in which the plants grow. Similar to surface water, many soils have a natural buffering capacity and are able to neutralize acid inputs. In general, soils that have a lot of lime (e.g., Bluegrass and Pennyroyal regions) are better at neutralizing acids than the sandstones and shales of eastern Kentucky. In less buffered soils, vegetation is affected by acid deposition. Acid deposition affects plants in the following ways: (1) higher acidity results in the leaching of important plant nutrients, including calcium, potassium, and magnesium; (2) low availability of these nutrients may cause a decline in plant growth rates; (3) aluminum (a toxic heavy metal) becomes more mobile in acidified soils and can damage roots and interfere with plant uptake of other nutrients; (4) reductions in soil pH can cause germination of seeds and the growth of young seedlings to be inhibited; (5) important soil organisms cannot survive in soils below a pH of about 6.0, and the death of these organisms can inhibit decomposition and nutrient cycling; and (6) acid precipitation can cause direct damage to the foliage on plants.

Small amounts of many elements including metals are deposited on the land and terrestrial plants from the stacks of power plants. In addition agricultural uses of water where metals deposition or discharges have occurred can also increase potential toxicity. The potential toxicity is determined by a number of factors including solubility of the elements and the make-up of the soil including cation exchange capacity, organic matter, drainage, and the effects of microorganisms and plant roots. Trace element deposition is most critical if the soil already contains the elements near a toxic level.

Site Stability

Another critical land issue for power generation plants is the stability of the site. Prior to siting, the possible impacts of flooding, earthquakes, subsidence from mining, displacement of mine spoil and potentially unstable fill or other types of instability must be considered. All of these events can disrupt power plant operations and pose a negative impact to the environment.

Secondary Impacts

Some environmental impacts related to electricity generation are not directly attributable to power plant operations. Other activities conducted to support the electric generating industry can also pose impacts to Kentucky's environment. These types of issues can be considered indirect impacts and are discussed here briefly.

Fuel Extraction

Many of Kentucky's power plants burn coal that has been mined within Kentucky. Over 60 percent of the coal burned by Kentucky power plants is mined in Kentucky. Historically, coal mining has had significant impacts on the environment. Deep mining practices have often caused acid mine drainage, land subsidence, the creation of old slurry impoundments, and gob piles. Surface mining practices often cause degradation or loss of ecosystems, habitat, and soil structure. Aquifers can be lost or contaminated by blasting. Also, the current practice of hollowfill techniques often destroy stream headwaters. In this process, unwanted mining wastes such as soil, rock, and waste coal are discarded by filling mountain hollows and small valleys. This destroys natural habitat, and can cause serious water quality problems such as siltation or acid drainage.

Some power plants burn oil and natural gas extracted from wells located in Kentucky. These wells also can have adverse impacts on Kentucky's resources if improperly constructed and managed. Drilling mud management, road construction, brine discharges, and tank spills are all issues associated with oil drilling. In addition, groundwater can become contaminated if wells are not properly sealed or closed after they are no longer in use. The construction of roads and tanks for natural gas drilling can cause habitat destruction. There is also the potential that these types of operations can impact scenic views in natural areas critical to Kentucky's tourist industry.

Fuel Refinement

Fuel refinement can also cause secondary impacts to Kentucky's environment. To ensure the fuel is an acceptable quality for electric generation, fuel processing and refinement is necessary. In the past, the petroleum refining process has caused significant discharges to ground and surface water as well as produced significant emissions to the air. Coal processing and washing facilities have at times created gob piles, burned gob piles, and caused acid drainage and leachate problems that have impacted Kentucky's natural environment.

Fuel Transportation

Transporting fuel to the power plants can also create environmental impacts. Coal is typically transported in trucks, trains, and barges. Each of these methods of transportation requires their own infrastructure, all of which can pose an impact to the environment during their creation and operation. Road, highway and rail systems destroy large areas of habitat and can impact streams and wetlands. Barge loading areas often require significant alterations of the natural stream flow and stream bottom, which can affect the aquatic species in that area. Each of these types of transportation are prone to accidents that can result in spills and other problems. In the past, many transportation accidents related to these fuels have been reported to the Cabinet each year. Another secondary impact related from fuel transportation is increased air pollution. Each of these transportation methods can increase area air pollution due to the emissions caused by these vehicles. Natural gas transportation is conducted through an extensive network of pipelines. As natural gas demand increases, there is the potential that more pipelines will be necessary to support additional drilling and the fuel demands for natural gas burning power plants. The associated construction can also pose problems for Kentucky's environment through soil runoff, sedimentation in streams, and habitat loss.

Power Transmission

There are also potential indirect impacts associated with the construction and operation of power substations and transmission lines. New transmission lines can impact the environment in areas where they are constructed by increasing the potential for runoff and habitat loss or fragmentation. There are also aesthetic considerations related to power transmission. Although, people benefit from inexpensive and reliable electricity, many people do not want to live near power plants and transmission lines. Environmental justice concepts can become issues when power line siting decisions are made.

Economic Development

A final secondary impact discussed in this report is economic development. As electricity is made available to communities, it often facilitates the development of the area economy. New businesses are established, factories are constructed, and the community can support additional residences. All of these things obviously provide significant benefits to Kentucky's residents and economy. However, it should be noted that this growth has an impact on the environment and proper consideration must be made to ensure those impacts are mitigated as much as possible.

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Appendix A

U.S. EPA CMAQ Modeling Results
Power Generation Units in Kentucky

Prepared by:

Kentucky Department for Environmental Protection

Division for Air Quality

Program Planning and Administration Branch

December 17, 2001

1. Introduction/Background

The Governor of Kentucky placed a moratorium on the acceptance of construction permit applications for any new power plants in Kentucky until December 7, 2001. During this interval, the Natural Resources and Environmental Protection Cabinet was directed to study the potential cumulative environmental effects of recently constructed and proposed electric generating capacity in the state. This document discusses the framework the Division for Air Quality used to determine potential environmental impacts from the increase in air emissions associated with the new and proposed electric generating units and also examines impacts from existing electric generating units.

Air pollution is hazardous to human health and the environment. It can irritate and damage the respiratory system and may produce long-term or chronic illnesses. People who have underlying health problems such as asthma and emphysema, the very young and the elderly, or people who work outdoors are more susceptible to the harmful effects of air pollution. Trees, crops, and other vegetation can be damaged by air pollution, and some air pollutants can also damage buildings, monuments, and other man-made structures. Visibility in many of our national parks and forests is hindered by air pollution.

Air quality modeling was performed to determine if emissions from proposed new generating units would have a detrimental impact on air quality within Kentucky, and if so, the magnitude of that potential impact. Modeling analysis was to examine impacts of criteria air pollutants including both 1-hour and 8-hour ozone levels, fine particulate levels, impacts on visibility, and acid deposition. However, due to modeling difficulties, no acid deposition analysis was performed, and the results of the investigation of visibility impacts were inconclusive.

The Commonwealth's ability to meet National Ambient Air Quality Standards for carbon monoxide, nitrogen oxides and sulfur dioxide with the addition of the proposed unit were not evaluated for this study. All areas of the state have air-monitoring data showing continuing compliance with those federal ambient air quality standards. Therefore, every attempt was made to focus on issues of importance within the state in this analysis.

Due to the short timeframe of this exercise, the division had to focus on a few issues of manor importance to the state. For example, potential impacts of the federal NOx SIP Call, which will drastically reduce NOx emissions across the eastern U.S., could not be included. When this analysis began, many existing power plants within Kentucky had not yet determined how they would comply with the SIP Call. Facilities have a choice of adding pollution controls or purchasing NOx allowances on the open market. Therefore, the analysis uses a “worst case scenario” and assumes existing utility emissions will continue at present. In addition, projected emissions reductions from mobile sources, such as cars, were excluded. As will be described below, an existing emissions inventory and modeling files for July 9-16, 1995, were used in the air model.

2. Participants

The U.S. Environmental Protection Agency, Office of Research and Development, Atmospheric Modeling Development Branch (AMD) was instrumental in providing potential impacts on ozone and particulate matter levels. At the request of Kentucky, a series of model simulations using the Community Multiscale Air Quality (CMAQ) modeling system were performed in an attempt to quantify impacts from new electric generating units and existing impacts of units already in operation. A detailed description of this model, how it was designed, and how it functions is included in this Appendix.

Funding for this project was provided to AMD through a holdback of supplemental federal 105 grant funds of $30,000. U.S. EPA contracted with Dyntel to perform the actual modeling. Analysis and interpretation of the modeling was performed by the Division for Air Quality.

3. Data Collection

Typically, an analysis of this type would take approximately two years and several thousand dollars to complete. An inventory of emissions would have to be developed. Review and research of periods of time to be modeled would be performed and typically, two or more “episodes” or periods of several days would be chosen in order to provide a reasonable estimation of impacts. This provides a better picture of the impact of emissions during different meteorological conditions for a given area. Once all of these activities are completed, modeling begins. Sensitivity runs are performed to see if the model is able to duplicate actual monitoring conditions for that time span. This helps determine if the model is “over predicting” or “under predicting” pollutant levels. Once the model performance has been determined, modeling can begin for various potential emissions scenarios.

Due to time constraints, AMD suggested that an existing emissions database and model set previously used in the Southern Oxidant Study (SOS) to investigate ozone formation in the southeast be used for Kentucky’s analysis. That existing data set is for the period of July 9-16, 1995.

A review of existing monitoring data in Kentucky for that period shows it to be an appropriate and conservative period to use in the investigation. Violations of the 1-hour ozone standard occurred within each of the major metropolitan/urban interstate areas

(Louisville/Southern Indiana, Cincinnati/ Northern Kentucky, and Ashland/Huntington) and numerous exceedances of the 8-hour ozone standard occurred throughout Kentucky during that time. Fine particulate matter standards were not in place in 1995. Therefore, no historic monitoring data exists for comparison. The following tables show the location and level of the exceedances for both the 1-hour and 8-hour ozone standard during the July 9-16, 1995, period.

1-Hour Ozone Standard Exceedances
July 9-16, 1995

County	Date	Level
Louisville Area		
Jefferson	7/12/95	0.129
Ashland/Huntington area		
Cabell County, WV	7/13/95	0.130

County	Date	Level
Northern Kentucky/Cincinnati area		
Warren County, OH	7/13/95	0.144
Warren County, OH	7/14/95	0.128
Butler County, OH	7/12/95	0.133

8-Hour Ozone Standard Exceedances
July 9-16, 1995

County	Date	Level
Pike	7/11/95	.085
Pike	7/13/95	.086
Fayette	7/10/95	.089
Fayette	7/11/95	.088
Fayette	7/12/95	.104
Fayette*	7/14/95	.088
Scott	7/12/95	.099
Scott	7/13/95	.088
Scott	7/14/95	.087
Daviess	7/13/95	.096
Daviess	7/14/95	.085
McLean	7/11/95	.103
McLean	7/12/95	.093
Hancock	7/11/95	.095
Hancock	7/12/95	.101
Hancock	7/13/95	.086
Hancock	7/14/95	.095
Henderson*	7/11/95	.098
Henderson*	7/12/95	.097
Henderson*	7/14/95	.097

County	Date	Level
Campbell	7/12/95	.098
Campbell	7/14/95	.091
Kenton	7/12/95	.098
Kenton	7/15/95	.085
Boyd	7/10/95	.085
Boyd	7/12/95	.091
Boyd	7/13/95	.103
Boyd	7/15/95	.102
Bullitt	7/10/95	.090
Bullitt	7/12/95	.086
Bullitt	7/14/95	.105
Oldham	7/11/95	.088
Oldham	7/12/95	.088
Jefferson*	7/12/95	.103
Jefferson*	7/14/95	.102
Jefferson*	7/16/95	.085
Hardin	7/11/95	.087
Hardin	7/12/95	.095
Hardin	7/14/95	.095
Livingston	7/14/95	.092

**More than 1 monitor in the county recorded an exceedance of the standard on this date. This exceedance level was the highest.*

U.S. EPA had existing modeling data sets and inventory files developed for a 36 kilometer grid which included a large portion of the eastern U.S. and a 12 kilometer grid set-up which included all of Kentucky. U.S. EPA agreed to re-grid Kentucky into a separate four kilometer grid in an attempt to more accurately document any potential impacts from the addition of the new and proposed power plant emissions within Kentucky's borders. This alteration of emission and meteorological data was time consuming, but results from this analysis should be more representative of potential air quality impacts occurring in Kentucky from sources within the state.

Base year 1995 emissions data, in tons per summer day, already existed and were used in the SOS study. U.S. EPA provided Kentucky with the emissions data and a comparison of the 1995 point source data was compared against Kentucky's 1995 Emissions Inventory database and found to be fairly similar. Information for area, mobile, and biogenic (naturally occurring) emissions, also appeared to be fairly representative of other modeling inventories used in various modeling studies in the past. Kentucky has performed extensive inventories in the past in areas where air quality problems existed, however, a statewide inventory for categories other than industry sources has not been performed in Kentucky. The following table outlines 1995 emissions used in the modeling.

1995 Air Emissions

(*tons per summer day*)

Emission Category	CO	NOx	VOC	PM10	PM2.5	SO2	Ammonia
Point Sources	289	1,250	371	97	36	2,377	3
Mobile Sources	2,641	375	364	15	12	15	13
Area Sources*	1,179	582	575	764	202	250	237
Biogenic (naturally occurring)		103	7,259				
TOTALS	***4,109***	***2,310***	***8,569***	***876***	***250***	***2,642***	***253***

**For purposes of this study, area sources include non-highway emissions.*

Kentucky provided emissions data to U.S. EPA for electric generating units permitted since 1995 that were not included in EPA's initial inventory. Kentucky also provided and potential emissions data for the remainder of the proposed units based on information in air permit applications. Additional information such as unit location and stack parameters, including height, diameter, and flow rates, was also provided. This information was essential for determining any new source impacts on air quality. U.S. EPA then used this revised inventory data to add the proposed emissions from the new electric generating units in Kentucky to the model. The following table outlines those emissions and where they are anticipated to occur.

Projected New Power Plant Emissions
(tons per summer day)

County	CO	NOx	VOC	PM10	SO2
Breckinridge	0.41	0.65	0.10	0.14	
Campbell	0.45	0.27	0.22	0.12	
Clark	5.35	13.31	0.95	1.06	10.77
Estill	2.50	1.02	0.13	0.17	1.73
Henderson	18.29	14.86	0.44	2.47	14.26
Jefferson	0.01	0.13			
Kenton	0.67	0.36	0.20	0.12	0.02
Knott	16.54	4.30	0.44	0.92	7.96
Lawrence	0.67	0.68	0.09	0.05	0.02
Marshall	20.18	6.95	0.85	1.68	8.16
Martin	16.54	4.30	0.44	0.92	7.96
Mason	4.50	3.00	0.11	0.90	6.00
Metcalfe	1.44	1.12	0.05	0.05	0.02
Muhlenberg	18.08	16.52	1.39	3.61	30.01
Oldham	0.67	0.26	0.05	0.05	0.02
Trimble	10.68	6.12	0.70	1.29	0.09
Totals	**117**	**74**	**6**	**14**	**87**

4. Methods

While the modeling grid was altered to reflect the four kilometer level, additional verification of 1995 and proposed emissions was performed and the modeling files updated as necessary. When the alteration was complete, U.S. EPA began the actual model runs. The first runs were the “base case” runs which provided modeled 1995 pollutant levels. These served as the base level on which further analysis of subsequent runs would rely.

U.S. EPA then added the emissions from the new and proposed electric generating units. The model was once again run and plots showing the difference between the base case and the runs with the additional emissions were generated. This difference represents the estimated impact of emissions from new and proposed electric generating units on air quality in the state.

The next step was to "zero out" all existing utility emissions data in the 1995 data base and again run the model. The results were plotted to provide an estimate of the <u>difference</u> in pollutant concentration after removing those emissions. From that result, an estimate of pollutant impact from existing electric generating units for the July 9-16, 1995, time period is obtained.

5. Results

Overall

The U.S. EPA provided Kentucky with emissions data and meteorological plots used in the modeling. For the period July 9-16, 1995, plots showing base case modeling results, difference plots showing impacts from additional new electric generating units, and difference results after taking out all existing power plant emissions were provided by U.S. EPA for each of the eight days. These plots, along with meteorological plots, are included in this appendix.

The following tables outline the 1995 pollutant contribution used in the base case modeling and compares the emissions from the existing electric generating units to the new and proposed units.

Emissions used in U.S. EPA Modeling

(*tons per summer day*)

1995 Base Year Emissions

Emission Category	CO	NOx	VOC	PM10	PM2.5	SO2	Ammonia
Point Sources	289	1,250	371	97	36	2,377	3
Mobile Sources	2,641	375	364	15	12	15	13
Area Sources*	1,179	582	575	764	202	250	237
Biogenic (naturally occurring)		103	7,259				
TOTALS	4,109	2,310	8,569	876	250	2,642	253

For purposes of this study, area sources include non-highway emissions.

Total New & Projected Power Plant Emissions

Emission Category	CO	NOx	VOC	PM10	PM2.5	SO2	Ammonia
ADDITIONAL ELECTRIC GENERATING UNIT EMISSIONS	117.	74.	6.	14.		87.	

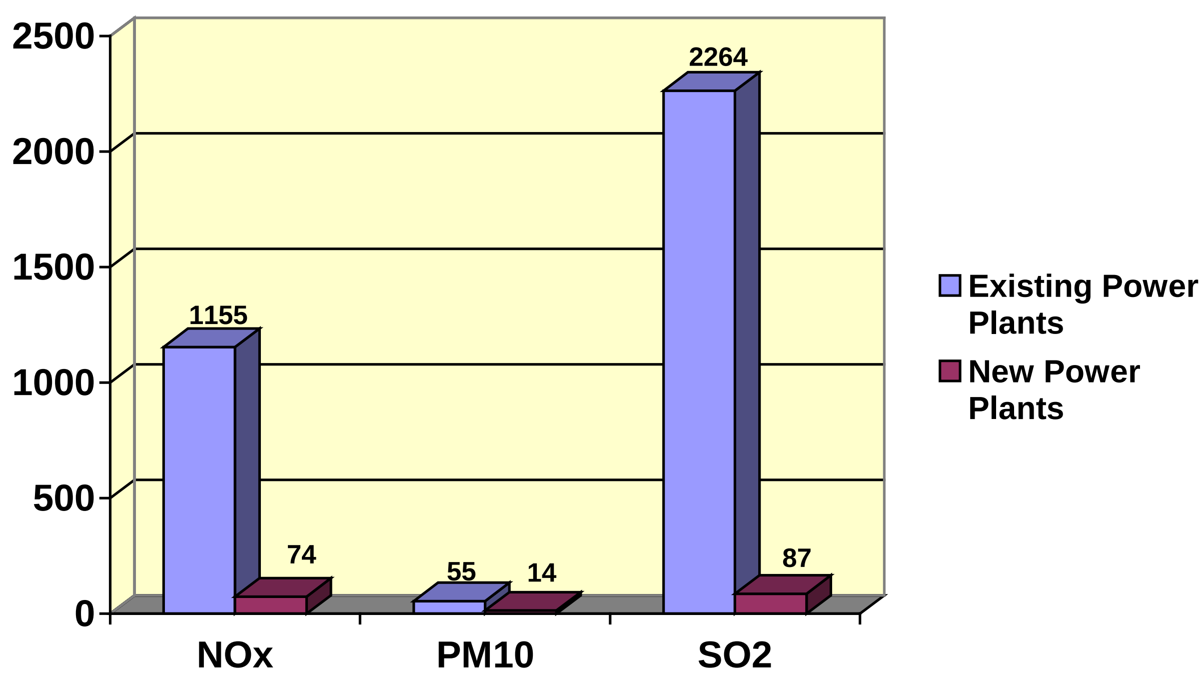
1995 Emissions from Existing Electric Generating Units

Emission Category	CO	NOx	VOC	PM10	PM2.5	SO2	Ammonia
1995 EXISTING ELECTRIC GENERATING UNIT EMISSIONS	34.	1,155	4.	55.	12.	2,264.	

A review of the 1995 emissions data shows that the existing electric generating units contribute 92 percent of the NO_x point source emissions and approximately 50 percent of the total NO_x emissions in the state. SO_2 emissions show an even larger contribution. The 1995 inventory shows existing electric generating units emit 95 percent of the point source SO_2 and 86 percent of the overall SO_2 emissions in the state.

The following chart compares these contributions with those being projected from the new and proposed electric generating units. New power plants are projected to increase NO_x emissions by 74 tons per summer day. That increase in emissions would provide a 3 percent increase in overall NO_x emissions for the 1995 inventory. SO_2 emissions, as a result of the new plants, are projected to increase an additional 87 tons per day. This increase represents a 3 percent increase over base year 1995 SO_2 emissions.

Power Plant Emissions
1995 Existing Emissions
compared to
New & Projected Emissions



Ozone

The unique chemistry involved in ozone formation provides reactions that are not linear in nature. Adding an additional amount of NO_x or VOC emissions to a mix does not give an equivalent increase in ozone formation. The same can be said with emission decreases. If emissions are decreased by a certain percentage or amount, a like ozone reduction is not obtained.

In order to determine results from the modeling, a detailed analysis of the point of maximum impact for each day of the modeling episode was used. Once the maximum point of impact had been determined, a review of the 1995 base modeling was performed to determine the modeled concentration in that area. A percentage of change was derived using the maximum impact difference divided by the base concentration level for that particular area.

Example – July 9, 1995

Maximum point of modeled Kentucky impact from additional emissions was in the Livingston County area -- 0.066 ppm difference. The base modeling showed a modeled concentration of approximately 0.08 ppm for that date. The percent difference between the modeled concentration and the modeled base was 7.5 percent.

Once that percentage had been derived, a review of actual monitoring data for that date in Livingston County showed that the highest 1-hour value for that day was 0.066 ppm. For purposes of this impact analysis, Kentucky assumed a ten-percent reduction in ozone levels statewide due to the implementation of the federal NOx SIP Call. U.S. EPA has estimated that the potential decrease in ozone concentrations due to new lower NO_X limits may be up to 20 percent. However, this study is designed to provide a “worst case scenario” in determining potential impacts, so only a ten-percent ozone reduction is used.

The actual monitored value for that day (July 9) was multiplied by 90 percent (to take into account the ten-percent reduction from the SIP Call) and then multiplied by the percent increase projected by the modeling. In discussions with U.S. EPA about appropriate methodologies for determining impacts to air quality in Kentucky, U.S. EPA agreed that this method was appropriate.

Recognizing that the base modeling did not always duplicate actual monitored values, a review of other areas of the state where elevated ozone levels occurred in Kentucky for the July 9-16, 1995, period was also conducted. Using the same type of analysis for those areas, changes in the actual monitored data were compared to the percentage of change in the modeling from the comparison of the percent increase over the modeled base. The ten-percent reduction in anticipation of the NOx SIP Call was also taken in these instances. Detailed spreadsheets outlining the location of maximum impacts for both the 1-hour and 8-hour study are attached to this appendix.

1-hour Ozone

The 1-hour ozone standard is set at .120 parts per million (ppm). One exceedance of the 1-hour standard occurred during the July 9-16, 1995, timeframe in Jefferson County. Four additional exceedances occurred in air sheds that contain parts of Kentucky, including Cincinnati/Northern Kentucky and Huntington/Ashland. Elevated 1-hour levels occurred in other parts of the state, with monitored readings of 0.100 ppm or greater during that time. All areas of the state have air quality monitoring data meeting the 1-hour ozone standard at this time.

Proposed Units

Projected emissions from the new electric generating units are anticipated to add an additional 74 tons per day of NOx. Additional VOC emissions are minor and projected to be 6 tons per day. Based on the modeling, adding the new power plant emissions to those already in existence may increase anticipated daily 1-hour ozone levels 0.006 – 0.014 ppm in areas downwind of the new plants. This range represents a 6.25 percent to 13.33 percent increase in anticipated 1-hour ozone levels. The greatest impacts in the simulation occurred on July 14 & 15, 1995, where the differences of 0.12 and 0.14 ppm respectively were projected in grid cells in western Kentucky. Coupled with projected reductions in 1-hour ozone readings resulting from future implementation of the NOx SIP call, 1-hour ozone values throughout the state should remain below the 0.120 ppm standard after all of the new power plants are in operation.

Existing Units

The second round of modeling, where all emissions for existing electric generating units were taken out, showed a wide range of impacts. Maximum decreases in ozone concentrations range from 0.039ppm to 0.089 ppm. Additionally, decreases ranging from 0.003 ppm to 0.024 ppm were modeling in broad areas of the state. Eliminating existing unit emissions actually caused a slight increase on 1-hour ozone levels in some urban areas on various days throughout this period.

8-hour Ozone

The 8-hour ozone standard, adopted by U.S. EPA in 1997 is set at 0.08 ppm. This standard has been challenged in court. The U.S. Supreme Court ruled that U.S. EPA has the constitutional authority to set a standard, but that the implementation methodology set by U.S. EPA is in error. In addition, the Washington D.C. Circuit Court is also expected to hear arguments in December on the standard set and whether U.S. EPA adequately considered potential beneficial health impacts of ozone. Until these court challenges are resolved and U.S. EPA has completed its rulemaking and adopted a new implementation strategy, no designations of areas meeting or not meeting the 8-hour standard can be made. U.S. EPA is projecting that it will be 2004 before official designations under this standard are made.

However, under the 1990 Clean Air Act Amendments, states are under obligation to submit information on air monitoring results in response to the 8-hour standard. In June 2000, Kentucky submitted a list to U.S. EPA of counties that had the potential to be designated as not meeting the 8-hour ozone standard. That list was based on 1997-1999 air monitoring data. The most recent monitoring data, 1999-2001, indicate that the list should be revised. In addition, monitoring data for each of these areas may change. However, there are some areas of the state that would be designated as non-attainment for the 8-hour ozone standard if designations were made now. Counties other than those included in the following list may be designated as non-attainment if they have emissions that impact the listed counties.

Counties with ozone monitoring data in violation of the 8-hour ozone standard

1999-2001 Air Monitoring Data

Boone	***Boyd***	***Bullitt***	***Campbell***
Christian	***Edmonson***	***Greenup***	***Jefferson***
Kenton	***Livingston***	***McClean***	***Oldham***
Pulaski	***Simpson***		

Proposed Units

Based on the modeling, adding the new power plant emissions to those already in existence may increase anticipated daily 8-hour ozone formation from 0.003 ppm to 0.011 ppm in areas downwind of the new units. This range represents a 3.75 percent to 11 percent increase in anticipated 8-hour ozone levels. The greatest impacts in the simulation occurred on July 14 & 15, 1995, where differences of 0.11 ppm were projected in Western Kentucky. Even coupled with the expected benefits from the NOx SIP Call, the model shows that the additional emissions from new generating units could impact 8-hour ozone values in various parts of the state. Some areas may even fail to meet the 8-hour standard. The modeling indicates an increased potential for this problem in the Lawrence/Boyd County area and the Daviess/Henderson County area from additional emissions associated with the Dynegy Riverside facility in Lawrence County and the Grane and Cash Creek facilities in Henderson County.

Conversely, in a few instances, increasing NOx emissions actually decreased ozone formation to a slight degree, in specific small areas.

Existing Units

The second round of modeling performed for the 8-hour standard, where all emissions for existing electric generating units were removed, showed a wide range of impacts. The overall effect was that existing power plant emissions appear to have a greater impact on a wider scale than the emissions from the new plants. This is to be expected since the total amount of emissions from the existing electric generating units is much larger than the total amount from the new units. A decrease in ozone formation from .021 ppm to .056 ppm was seen in Kentucky during this model run. The maximum decrease in Kentucky occurred in July 15 data set, toward the end of the episode, in Western Kentucky. Additional reductions were projected to occur over a more regional/state scale each day of the period.

There were some instances of "disbenefit" in areas. This means that in some instances, zeroing out all power plant emissions in the state actually showed an increase in projected ozone concentrations, generally in urban areas.

Fine Particulate Matter

Fine particulate has two standards, a 24-hour concentration standard which is set at 65 micrograms per cubic meter (ug/m3) and an annual standard set at 15 ug/m3. These standards did not exist in 1995, so no historic monitoring data exists for comparison. However, a comparison can be made to recent fine particulate in an attempt to correlate projected emissions increases to present day monitoring results. Based on recent monitoring reports, Kentucky has no areas out of compliance with the 24-hour fine particulate standard, but has several areas which could fall out of compliance in the future.

Modeling was performed by U.S. EPA for fine particulate and for sulfates which is a subset of fine particulates. For fine particulate, hourly average concentrations and changes in those concentrations were determined for the addition of proposed power plant emissions and the removal of existing power plant emissions.

Due to the short time for completing the modeling exercise, U.S. EPA was unable to perform the routine base simulation model evaluations and was only able to perform limited quality assurance on the output runs. U.S. EPA has noted that they are fairly confident of the modeling results within Kentucky, but not as confident on results outside Kentucky's boundaries.

Proposed Units

New electric generating units contribute fewer emissions of fine particles than existing power plants. Projected SO_2 emissions from proposed new power plants are anticipated to be approximately 87 tons per summer day. The U.S. EPA model projects the additional emissions from the new electric generating units will contribute insignificant amounts in limited areas throughout the state. Impacts of up to 1.144 ug/m3 for an hourly average are shown in the results and these impacts are generally in areas with proposed new units.

The second round of modeling performed by U.S. EPA for the fine particulate standard, where all emissions from existing electric generating units were removed, showed a wide range of impacts. In general, existing coal burning electric generating units play a significant role in fine particulate formation. Existing units generate approximately 2,264 tons of SO_2 per summer day. In Kentucky, maximum contributions up to 23.75 ug/m3 for an hourly average were modeled. However, some degree of impact is seen on a wider regional/state scale for each day of the modeling analysis.

The separate modeling performed for sulfates mirrors the results of those found for total fine particulate. Modeled increases are seen in very limited areas with a range from 0.284 through 1.0 ug/m3.

Visibility

In our nation's scenic areas, the visual range has been substantially reduced by air pollution. In eastern parks, average visual range has decreased from 90 miles to 15-25 miles. Typically, in Kentucky, sulfates and to some extent nitrates, are the major contributors to decreasing visibility.

While there is no one definition of visibility that meets all the criteria of "seeing" landscape features, a number of visibility indices have evolved. Gauging whether visibility is getting better or worse is sometimes expressed in terms of "deciviews." Deciviews represent the improvement/worsening of visibility. For example, visibility up to 130 kilometers is equivalent to 11 deciviews. Increasing deciviews to 14 decreases visual range down to 100 kilometers.

U.S. EPA's modeling shows what would be considered base visibility, gauged in deciviews, and attempts to show a change (in deciviews) when emissions are added or taken away. The results from this modeling exercise are inconclusive and this model does not appear to be an appropriate tool for purposes of determining visibility impacts for this study.

A more accurate representation of whether emission sources may impact visibility can be accomplished using the CALPUFF model recommended by U.S. EPA and the Federal Land Managers. This model has been used by some new power plant permit applicants with a few results showing impact to Class I areas.

6. Uncertainties

Uncertainties exist anytime potential is examined. This modeling study to determine the impacts of electric generating unit emissions on air quality in Kentucky cannot provide an exact and accurate description of the future. Rather it provides information that can assist in gauging the impacts of proposed power plants.

The short time available for completing the study made it necessary to use many assumptions in the final analysis. For example, the use of the 1995 emissions database and modeling files do not represent emissions as they exist today, nor what emissions will be in 2004 when the majority of these new electric generating units will be in operation. Since 1995, changes have occurred in industrial emissions and mobile and area source categories. Pollution controls have been added or changed, fuel has varied and weather conditions have fluctuated. However, in order to complete the study, the 1995 database was the most comprehensive attainable within the time constraints. The emissions data and modeling files had previously been used in the Southern Oxidant Study (SOS) which is a comprehensive study of ozone formation for the southeast U.S. Although the 1995 inventory is not current, it provides a good basis for the study.

The future impact of the NOx SIP Call on Kentucky air quality is another uncertainty. U.S. EPA has projected that the NOx SIP Call may decrease ozone levels up to 20 percent. Additionally, other national emission reduction measures are on the horizon and could be in place by 2004. These include low sulfur fuels (gasoline and diesel), and new tier II controls for motor vehicles which will mean tighter emission restrictions on light trucks and sport utility vehicles. Off-highway mobile equipment will also have emissions decreases in the near future. Impacts from these future emission reduction measures have not been taken into account in this analysis but are expected to have an impact on ozone and fine particulate concentrations.

This modeling study was limited to the period of July 9-16, 1995, which represents one meteorological episode. Most modeling exercises use at least two or typically three different episodes in an effort to determine impacts from emission increases and decreases. If additional episodes with different meteorological conditions had been used, maximum impact levels and locations might have been different.

The relatively small increase in overall emissions caused by the new electric generating units also presents an uncertainty. U.S. EPA has stated in the past that increases or decreases in emissions of less than 10 percent may not show a modeled impact. The anticipated increase in NO_x and SO_2 emissions from the new power plants are estimated to be 3 percent.

Finally, there is the unpredictability of ozone and fine particle formation. The modeling depicts possible impacts when meteorological conditions are the same as those in the model files. This modeling should not be viewed as indicating an absolute emissions increase or decrease or that the impacts will be the same for each coming year. The modeling should be used as one tool of many for gauging the potential impacts from emissions changes.

7. Conclusions

The analysis of cumulative impacts of new and existing power plants on air quality in Kentucky has been limited by the time and resources available to complete the project. Timeframes were extremely compressed such that emission inventory development and modeling runs were conducted within a three month window. More definitive exercises necessary to develop a higher level of confidence in an air quality modeling study and conclusions drawn from that study would likely have required up to two years or more to complete, and considerably more funding. Further, the analysis was restricted to one series of consecutive days in 1995. Typically in a study of this type, more than one time period is modeled due to the impact of different meteorological conditions.

This modeling exercise predicted ambient air quality levels which were generally in the range of actual air monitoring results which have been collected for ozone during that time. But the differences between modeled and monitored values was somewhat unpredictable and at times fairly substantial. Assumptions were made that actual monitored ambient air quality readings would increase by the same percentage as the percentages seen in the modeling.

The model utilized emission data for all sectors – mobile, area, point, and biogenic (natural sources). Emissions expected from new power plants are dwarfed by the current emissions from existing power plants, and are even smaller when compared to the overall emission inventory totals from all sources. Clearly, the impacts from electric generation are more significant from the existing facilities than that predicted from new facilities.

The new power plant emissions appear to pose no problems for future compliance with the 1-hour ozone standard and appear to have little impact on future compliance with the short-term 24-hour fine particulate standard. The modeling was inconclusive regarding visibility impacts and no conclusions are being drawn regarding visibility. The one issue of some significance is related to the 8-hour ozone standard.

Official determinations of compliance with the 8-hour ozone standard have not been made at this point and may not occur until 2004 or 2005. Air quality monitoring data has been collected for a number of years and indicates that several areas of the state are not complying with the 8-hour standard. At least the Ashland and Henderson/Owensboro areas would appear to be adversely impacted by the increased emissions respectively from Dynegy Riverside in Lawrence County and the Grane Creek and Cash Creek facilities in Henderson County, but further consideration is warranted.

Coupled with the increase in emissions which Kentucky will experience from new power generation facilities is a substantial decrease in NOx emissions from existing power plants mandated by the NOx SIP call. These reductions are to be achieved by May 2004. While these reductions alone do not appear to fully resolve the 8-hour ozone compliance issues in these two areas, the analysis indicates that significant improvements will occur. Mechanisms will exist in the federal requirements currently being developed to guide states in enforcing the 8-hour standard and to identify actions states should take if noncompliance situations are encountered after the emission reductions from the NOx SIP Call have been achieved. It seems prudent to await further air quality information as well as federal guidance before speculating on further specific emissions reductions which might be appropriate.

A decision to restrict the authority of new power generating facilities to operate would be counter to the philosophy that some accommodation should be made for less polluting facilities. The gas-fired and coal-fired facilities recently permitted or currently under review will emit much less pollution per unit of electricity generated than any existing coal fired power plant. While it is not the intent of this report to suggest further controls on existing facilities, it does seem prudent to establish a position which balances the needs of existing, high emitting facilities with the general public need for more electricity at the lowest emission rates possible.

Finally, there should continue to be close attention paid to the number and location of power plants being proposed. Assurance should be received by regulatory agencies that all existing regulations will be met by new facilities. If a local air quality impact of significant proportions is encountered during review of an application, that issue should be dealt with on its own merits. Ambient air quality monitoring and analysis of data should continue to be conducted in a high quality manner. As federal air quality standards and implementation requirements are finalized by U.S. EPA and/or reaffirmed by federal courts, Kentucky to meet those expectations. Emission reductions required from the NOx SIP call must be achieved. If air monitoring data later shows that the tremendous emission reductions attained through power plant controls, cleaner diesel fuel and gasoline and cleaner operating diesel and gasoline engines do not deliver the required air quality, Kentucky will consider additional measures at that point to attain the air quality goals within the specified timeframes. Such future controls, if eventually deemed necessary, should take into account local emission contributions and needs for each area where improvements may be necessary.

Appendix B

Air Toxics Analysis for Proposed and Existing Electricity Generating Units in Kentucky

Prepared by:

Kentucky Department for Environmental Protection

Division for Air Quality

Program Planning and Administration Branch

December 17, 2001

Introduction

On June 19, 2001, Governor Paul Patton issued a Moratorium on Permits for New Power Plants. The Natural Resources and Environmental Protection Cabinet was directed to study the potential environmental impacts from increased generating capacity. This assessment of air toxics impact was conducted in conjunction with the study being conducted by the Natural Resources and Environmental Protection Cabinet.

Almost all of the state's power plants use combustion of fuel in the process of generating energy. Fuels for power plants include coal, waste coal, natural gas, fuel oil, and municipal garbage. As a result of burning large amounts of these fuels, there is the potential for releases to the environment. Air releases of toxic pollutants are of concern. Emissions controls are implemented to reduce the amount of contaminants released to air. This study was conducted to estimate the potential impact on ambient air and human health receptors from selected new and proposed Electricity Generating Units (EGUs) in Kentucky. In order to estimate these impacts it was necessary to use computer modeling of air dispersion. ISC-PRIME version 3.5.1 was the computer model used in this analysis.

Data Evaluation

Air toxics associated with power plants were analyzed to identify the pollutants that would have the greater impact, based on the magnitude of their emission rate and the Risk-Based Screening Value (RBSV) for that contaminant. As a result of that comparison, thirteen toxic air pollutants were selected for dispersion modeling in this study. This initial screening of pollutants eliminated compounds from this study if their emission rates were low and their risk based screening values were high in comparison to the thirteen chosen to be included.

The Screening Value is a concentration in a medium (soil, water, air, fish tissue) that is calculated based on exposure to that medium and the toxicity of that pollutant. These values were calculated by the Kentucky Department of Environmental Protection to reflect potential human health effects from exposure to these chemical compounds. This analysis estimates exposure due to inhalation only.The RBSV represents a one-in-a-million human health risk for cancer-causing effects or a Hazard Index of 1.0 for systemic (noncancer) effects. More detail on the calculation of screening values is given in Appendix G, Derivation of Human Health Screening Values. The thirteen air toxics included in this study are listed below.

POLLUTANT	RISK BASED SCREENING VALUE
Arsenic	$2.81 \times 10^{-4} \mu g/m^3$
Beryllium and compounds	$5.03 \times 10^{-4} \mu g/m^3$
Cadmium and compounds	$6.70 \times 10^{-4} \mu g/m^3$
Total Chromium	$1.10 \times 10^{-4} \mu g/m^3$
Lead (tetraethyl)	$2.16 \times 10^{-1} \mu g/m^3$
Mercury	$6.48 \times 10^{-2} \mu g/m^3$
Nickel	$5.03 \times 10^{-3} \mu g/m^3$
Formaldehyde	$9.28 \times 10^{-2} \mu g/m^3$
Benzene	$1.56 \times 10^{-1} \mu g/m^3$
Chloroform	$5.25 \times 10^{-2} \mu g/m^3$
Hydrogen Chloride	$4.32 \ \mu g/m^3$
Benzo(a)Pyrene	$1.40 \times 10^{-3} \mu g/m^3$
Dioxins	$2.82 \times 10^{-8} \mu g/m^3$

Selection of EGUs to be Modeled

EGUs were included in this study based on their size, location, fuel source, and proximity to other electricity producing plants. A conservatively representative sample was identified and modeled. For instance, the existing coal fired plant and the proposed 1,020 MW natural gas fired plant in Trimble County were not included because a very similar situation in Lawrence County was included. The existing coal fired plant (Big Sandy) is much larger than the existing plant in Trimble County and the proposed natural gas fired plant (Dynegy-Riverside) is similar to the proposed Trimble County plant. In addition, the terrain in Lawrence County is much more complex than that in Trimble

County. Therefore the inclusion of the two plants in Lawrence County is a conservative representation of the EGUs in Trimble County. The EGUs modeled are:

Proposed EGU	Size (MW)	Fuel	County
Kentucky Western Power	500	Waste Coal	Marshall
Kentucky Eastern Power	500	Waste Coal	Martin
Kentucky Mountain Power	500	Waste Coal	Knott
Thoroughbred	1,500	Coal	Muhlenberg
Cash Creek	500	Coal	Henderson
Dynegy-Riverside	1,040	Natural Gas	Lawrence
Global/Pioneer	540	Gasified Coal& Gasified Garbage	Clark
J.K. Smith Station	400	Natural Gas	Clark
Duke Energy	640	Natural Gas/Oil	Marshall

Existing EGU	Size (MW)	Fuel	County
Green Station	484	Coal	Webster
Reid/Henderson Station	450	Coal	Webster, Henderson
Green River	265	Coal	Muhlenberg
Wilson Station	440	Coal	Ohio
TVA Paradise	2,558	Coal	Muhlenberg
Big Sandy	1,096	Coal	Lawrence

In addition to modeling individual EGUs, five clusters of these facilities were identified and modeled as a group. These clusters consist of new and existing plants. They are:

Marshall County Cluster

Kentucky Western Power

Enron

Duke Energy

Westlake

Henderson County Cluster

Grane Creek

Cash Creek

Green Station

Reid/Henderson Station

Muhlenberg County Cluster

Green River

Wilson Station

TVA Paradise

Thoroughbred

Dynegy-Riverside/Big Sandy (Louisa)

Global Pioneer/JK Smith

It should be noted that conservative assumptions were made throughout this analysis. The following sections of this report will describe the model used and the assumptions associated with the modeling.

Emissions data

Where emissions data on any of the 13 toxic air pollutants included in this study was not provided by the owner/operator or the applicant it was estimated based on USEPA AP-42 emission factors for coal, fuel oil or natural gas combustion. These factors are based on emissions from many sources and should be considered as average values. In the case where a fuel with unusually high Nickel content might be burned, the impact of this pollutant would correspondingly be higher than that given by USEPA emission factors. Only ongoing fuel sample analyses or speciated stack testing can yield highly accurate emissions data.

Note that as a conservative assumption, all polycyclic organic matter was treated as Benzo(a)Pyrene since it has the lowest RBSV of all similar compounds known to be generated by combustion processes. In reality, compounds such as Chrysene and

Dibenz[ah]Athracene make up a portion the polycyclic organic emissions. However, these compounds have similar or lower RBSVs and it is therefore a conservative assumption to treat all polycyclic organic matter as Benzo(a)Pyrene.

Duke was conservatively modeled individually as if it were firing diesel fuel for the entire ozone season (March 1, through October 31).

In the cases of Kentucky Eastern, Mountain, and Western Power it was assumed that waste coal (GOB) would have the same characteristics as coal and emissions could therefore be estimated using the AP-42 emission factors. With the exception of Duke Energy in Marshall County which was modeled using the conservative assumption that diesel fuel will be used as the primary fuel, all facilities were assumed to be operating at full load and steady state 8,760 hours per year. For peaking stations this is a conservative assumption since they are expected to operate during the summer months only. Start ups, shut downs, and malfunctions were not analyzed due to the almost infinite number of possible scenarios and permutations of these situations. It was assumed that the impact of such incidents would average out over the annual averaging period of the RBSVs.

Model Description

ISC-PRIME is a Gaussian Plume algorithm model and is approved by USEPA for near range ambient air impact analysis. This model takes into consideration, weather, terrain, stack height, stack temperature, exit velocity, emission rates, and building downwash. All modeling parameters are on the diskettes attached to this document.

Weather data for EGUs in the western part of the state was collected at Paducah while data from Jackson was used for sources in the southeastern portion of the state. Huntington data was used for two EGUs, one existing and on new, located in Lawrence County. Analyses were performed in order to find the most conservative weather data set available so it could be used in this study. Paducah 1991, Jackson 1988, and Huntington 82 were identified as giving the most conservative predictions.

Digitized terrain data was obtained from the USGS website. All other information was provided by the EGU operators or was estimated by the author using USEPA AP-42 emission factors.

The model takes the information listed above and predicts, in this case, annual average ambient concentrations. It also generates plots that show areas of user defined concentrations. The risk-based screening values described earlier were used as input for the model to show in the plots. Multiples (10 times the RBSV) and fractions ($1/10^{th}$ and $1/100^{th}$) of the RBSV were used to identify areas that exceed those target levels. This allows the user to evaluate how widespread the risks are, and examine how quickly the risks decrease with distance from those areas of higher risk. All relevant plots are included in this report.

The plots are in polar coordinates and have a radius of 10km with the exception of plots of the Muhlenberg County cluster which have a radius of 15km. These distances were chosen due to the fact that ISC-PRIME has proven to be very accurate out to 10 to 15 kilometers. Beyond that distance it begins to lose accuracy especially if very low concentrations are being predicted.

Results

The dispersion modeling output was evaluated by comparing the modeled annual average air concentration at the nodes in the modeled domain with human health risk-based screening values described in Appendix G. The data that are presented here are the contours that were developed for each of the modeled facilities and for each chemical of concern. The contours were produced based primarily on the screening value, and multiples of ten, one-tenth, and one-hundredth of the screening value. Other multiples were used to gather more information on the distribution of risks (e.g., 2X, 3X, 20X, 30X, etc.).

Based on the ISC-PRIME dispersion modeling output, there are four chemicals that exceeded their risk-based screening value. All four of these pollutants are carcinogens. There were three additional chemicals that exceeded one-tenth of the RBSV. Since several of the chemicals showed widespread levels at or above one-tenth of the screening value, they are able to contribute to the total risk at the facility. Because many chemicals have similar effects on an organ system (kidney, liver, bone) there is the potential for additivity of effects. Additivity may play a part when several chemicals may be below the threshold for effects (in this case the RBSV), but in conjunction with other chemicals that act on the same organ system, may cause effects even though none of the chemicals exceeded their screening value individually. The four primary contaminants of concern and the frequency of exceeding the RBSV and one-tenth of the RBSV are:

Contaminant	Exceedance of RBSV	Exceedance of 1/10 RBSV
Arsenic	27%	82%
Beryllium	9%	45%
Total Chromium	27%	73%
Nickel	18%	27%

The four contaminants that did not exceed the RBSV but were above one-tenth of the RBSV were:

Benzo(a)pyrene	(27% of the model runs)
Cadmium	(45%)
Formaldehyde	(9%)
Hydrogen Chloride	(27%)

These four contaminants are expected to have only a minor impact with only a few areas exceeding one-tenth of the RBSV for formaldehyde and hydrogen chloride, but cadmium had exceedances of one-tenth of the RBSV in several areas. The modeled domain of 10 km had exceedances for up to 25 percent of the modeled area. Benzo(a)pyrene could be a contributor to the risks at one location with up to 50% of the modeled area exceeding one–tenth of the RBSV.

Nine of the thirteen toxic air pollutants modeled did not exceed their respective RBSVs. Therefore, for these nine pollutants, there are no plots of the RBSV. In many cases, no impact is predicted at 1/10 of the RBSVs. For the contaminant to show up on the plot, it was often necessary to plot 1/100 of the RBSV. Chloroform showed no impact even at 1/100 its RBSV in all cases.

For the four pollutants that did show impacts at or above their RBSVs, plots of 10 times the RBSV were generated to identify areas of higher risk. In the case of the Henderson County cluster impact of total chromium exceeded 50 times its RBSV. A plot of 60 times total chromium's RBSV shows no impact. The conclusion is that the predicted impact of total chromium in the Henderson County cluster is between 50 and 60 times its RBSV.

The areas predicted to have significant ambient impact of air toxics are as follows:

Muhlenberg County Cluster	(Arsenic, Beryllium and compounds, Total Chromium)
Henderson County Cluster	(Arsenic, Total Chromium)
Global Pioneer/J.K. Smith	(Arsenic, Nickel)
Kentucky Eastern Power	(Total Chromium)
Duke Energy	(Nickel, Total Chromium)

Duke Energy in Marshall County and Kentucky Eastern Power in Martin County were the only plants to show individual impact greater than the any of the RBSVs.

EGUs in Jefferson County were not analyzed. However, it can be reasonably expected that they would have similar impacts compared to relatively sized coal-fired EGUs modeled in this study specifically, the Cane Run and Mill Creek facilities.

The moratorium directs NREPC to study the impacts of permitting new power plants in Kentucky. The data for the proposed power plants were compared to the total impacts and to the existing power plants. In general, the new facilities that were modeled did not as a group have a significant impact on the total modeled air concentration.

The Muhlenberg and Henderson County clusters contain several large existing coal-burning power plants. As a result, these areas are estimated to have ambient impacts at or above the RBSVs for the respective air pollutants. The analysis shows that the proposed EGUs (Grane Creek, Cash Creek in Henderson County, and Thoroughbred in Muhlenburg County) in these clusters do not by themselves significantly contribute to the exceedance of the various RBSVs. The obvious conclusion is that the existing coal-fired EGUs are causing significant ambient impact of arsenic, beryllium, and chromium.

The J.K. Smith plant shows relatively high emission rates of two compounds predicted to exceed their RBSVs (arsenic and nickel). However it should be noted that their emission estimates are based on the operating scenario of continuous firing of 90% natural gas and 10% fuel oil. Since fuel oil is known to contain trace amounts of heavy metals it is logical that this source would show significant impacts of these pollutants. The impacts of arsenic and nickel from this facility do not exceed 10 times their RBSVs.

Kentucky Eastern Power is located in very rough terrain. However, the impact area predicted at the RBSV for total chromium is very small as can be seen on the plot.

Duke Energy has applied to construct a gas and/or diesel fuel fired peaking station in Marshall County. If it is assumed that they will exclusively fire diesel throughout the entire ozone season, then nickel and total chromium impacts are predicted to exceed the RBSVs. This is a highly unlikely scenario however and it should be noted that the primary fuel is natural gas which shows little or no impact of these toxic air pollutants.

Kentucky Western Power did seem to have a significant impact on the total concentration of several contaminants in the Marshall County cluster. This facility appears to be a probable source of air concentrations of beryllium, and chromium at $1/10^{th}$ of the screening value, and cadmium, HCl and nickel at $1/100^{th}$ of the RBSV. Since the Marshall County cluster consisted of four proposed plants, then the impact of Kentucky Western Power is expected, since that facility will be a waste coal-fired plant and the others will be primarily natural gas-fired.

Uncertainties

The four toxic air pollutants that exceeded the RBSV are heavy metals found in differing amounts in coal. Therefore, emissions of heavy metals into the air will vary unless the metals content of the coal burned is assumed to be constant.

This study was unable to evaluate loading and long-term accumulation of heavy metals (such as mercury) in the environment. There is the potential for mercury to settle in water bodies and bioaccumulate and affect fish tissue for human consumption. Increase in soil concentrations of heavy metals over time from air deposition could not be evaluated in this study either.

Long-range transport of airborne contaminants could not be evaluated. Mercury releases to the air from power plants are expected to be a major source of environmental mercury. Other toxic air pollutants could be of concern, as well.

Because of the nature of the comparison to RBSVs, the chemicals were compared to the individual RBSV and additivity of exposure to multiple chemicals could only be evaluated qualitatively.

Conservative assumptions were used to calculate RBSVs and to model the air concentrations. Actual exposures and effects are expected to be less in other meteorological conditions and with different receptor characteristics.

Effects on ecological receptors were not evaluated. Potential effects on aquatic and terrestrial receptor could occur near power plants based on the volume of fuel that is burned.

Recommendations

All pollutants shown to have impacts exceeding their respective RBSVs are heavy metals and their compounds. The modeling predicts significant impact of total chromium in the Henderson and Muhlenberg County clusters. Furthermore, it is evident that the existing coal-fired EGUs are the major contributors to this impact.

Since total chromium is emitted in particulate form, it is recommended that more efficient controls (baghouses, scrubbers, electrostatic precipitators, etc.) be installed at existing coal-fired plants. In addition, the emission of heavy metals is directly related to the metal content of the coal burned. It is therefore necessary to periodically analyze samples of the coal to determine if and by how much the metal content is fluctuating.

It is also recommended that all coal and waste coal (GOB) fired EGUs (proposed and existing) periodically perform stack tests for particulate matter and speciate the sample for heavy metals such as chromium, and arsenic. This will yield much more accurate emissions data than that estimated from average USEPA emission factors and will reduce much of the uncertainty inherent in modeling analyses.

Appendix C

Surface Water Outfall Risk Evaluation

Prepared by:

Kentucky Department for Environmental Protection
Division of Environmental Services
Risk Assessment Branch

December 17, 2001

Introduction

On June 19, 2001, Governor Paul Patton issued a Moratorium on Permits for New Power Plants. The Natural Resources and Environmental Protection Cabinet was directed to study the potential environmental impacts from increased generating capacity. This assessment of surface water outfalls was conducted in conjunction with the study being conducted by the Natural Resources and Environmental Protection Cabinet.

In the course of normal operation, power plants often use water in the electrical generating process. Water withdrawal is necessary for use in boilers, cooling, and pollution control. Water that is not released in the air is released via an outfall into a surface water body. Facilities that release water through an outfall are required to obtain a permit from the Division of Water's Kentucky Pollutant Discharge Elimination System (KPDES) Branch. Water discharged from power plants may have several sources. Many facilities have ash ponds for settling of ash created from the burning of coal. Effluents from ash ponds make up a portion of water released from power plants. Water may be used in different processes in the plants including transporting ash from the combustion chamber and around the facility, mixing with lime or fine limestone that is sprayed into the process train to remove sulfur from the exhaust gases, or cooling equipment. Coal can also be transported as slurry from one site to another by pipeline. Water from coal transport could also be released from a facility. Runoff from rainfall events at a facility and coal pile runoff may also be a part of the facility's effluent. The water that makes up the outfalls from these power plants is likely derived from several different sources.

Surface Water Data Selection

Facilities with a KPDES permit are required to submit monthly monitoring results for their outfalls. These data are submitted monthly in the Discharge Monitoring Report (DMR) format. The DMR data are entered in the Permit Compliance System (PCS) database. The database contains the data that have been submitted for each facility. Of the 34 existing facilities, 26 have KPDES permits and eight do not. Three facilities have a common permit: Green, Henderson 2, and Reid. Of the 22 proposed plants, six will be covered by existing permits, and two others have already obtained a new permit. Other proposed plants are still in the early stages of the planning and permitting process and have not yet submitted a KPDES permit application.

Because of the number of facilities and data points in the database, it was decided that data from a subset of the total dataset would be analyzed. The Division of Water was consulted to obtain DMR data. Data from 1997-2001 were provided for the existing power plants in electronic format.

The initial dataset consisted of 44,168 data points for measured parameters. Since each record of the database is for a single monitoring parameter for a given date and outfall, the data were transformed into a table that presents all of the monitoring results for a given date and outfall in one row. The resulting table has 8,406 records for the outfalls during the 1997-2001 monthly monitoring periods.

Methods

The dataset for the DMR data was further condensed by focusing on the contaminants of particular concern for human health impacts. The primary contaminants of concern are the metals. Table 1 shows the parameters that would be evaluated for human health impacts and those that were removed from the dataset. Some of the parameters that were removed could be a concern for ecological impacts and were considered in Appendix E.

Table 1. Parameters That Were Retained for Human Health Risk Evaluation

Retained	Removed
Aluminum	Total Metals
Arsenic	Total Priority Pollutants
Cadmium	Fecal Coliform
Chromium	BOD
Copper	Chloride
Lead	Chlorination
Manganese	Chlorine
Mercury	Flow
Nickel	Hardness
Selenium	LC50
Silver	Nitrogen, Ammonia
Zinc	Oil and Grease
Polychlorinated Biphenyls (PCBs)	Oxidants
Iron	Dissolved Oxygen
	pH
	Phosphorus
	Precipitation
	Rainfall

After removing the parameters listed in Table 1, the remaining data were sorted to remove sampling events that contained no data for the parameters of concern. The final dataset that was evaluated for human health impacts contained 340 sampling events for the outfalls associated with power plants. Average flow rates for the receiving streams and outfalls are available in the permits on file in the Division of Water file room. The Division of Water provided 7Q10 and Harmonic Mean flow rates for each of the water bodies that receive the outfalls. The 7Q10 represents the ten year periodic, 7-day low flow conditions. They also provided mean annual flow rates for the outfalls. The flow rates are listed in Table 2.

Table 2. Flow Rates and Calculated Dilution Factors

Facility Name	County	Outfalls	7Q10 (cfs)	Harmonic Mean (cfs)	Annual Mean Flow of Outfall	Dilution Factor	
						Mean	7Q10
CINCINNATI G & E E BEND STEAM	BOONE		11000	57347	4.9 MGD avg 001	2522	484
EAST KY POWER COOP COOPER STAT	PULASKI	2	0	0	152 MGD avg 003	1	1
"	"	1,3,5,6,7	60	621		2	1
EAST KY POWER COOP DALE STEAM	CLARK		122	918	3.75 MGD avg 004	53	7
EAST KY POWER COOP SMITH STEAM	CLARK		122	875	no process ww		
EAST KY POWER COOP SPURLOCK ST	MASON		9800	50608	2.43 MGD avg 001	4488	869
HENDERSON POWER & LIGHT STA #1	HENDERSON		13000	78000	0.233 MGD avg 001	72132	12022
KY POWER CO BIG SANDY PLANT	LAWRENCE		25	25	6.06 MGD avg 001	2	2
KY UTIL E W BROWN GEN STA	MERCER		100	NA	6.66 MGD avg 001	4	4
KY UTIL GHENT GENERATING	CARROLL		11000	55900	15 65 MGD avg 001	770	151
KY UTIL GREEN RV GEN STA	MUHLENBERG		55	3893	6.98 MGD avg 001	120	3
KY UTIL PINEVILLE GEN STA	BELL		16	193	0.25 MGD avg 001	166	14
KY UTIL TYRONE GEN STA	WOODFORD		136	1033	3.72 MGD avg 001	60	9
LOUISVILLE G & E CANE RUN STA	JEFFERSON		13000	57400	7.05 MGD avg 004	1754	397
LOUISVILLE G & E MILL CRK STA	JEFFERSON		13000	57400	12.6 MGD avg 001	982	222
LOUISVILLE G & E PADDYS RUN ST	JEFFERSON				no process ww		
LOUISVILLE G & E TRIMBLE STA	TRIMBLE		13000	57400	no process ww		
OWENSBORO MUN UTIL SMITH STAT	DAVIESS		11000	65000	218 MGD avg 001	64	11
TVA KY HYDRO PLANT	LIVINGSTON				no process ww		
TVA PARADISE FOSSIL PLANT	MUHLENBERG	1,16,17	0	0	37.9 MGD avg 001	1	1
"	"	2,3,5,11,12, 13,14,15	450	3793		22	4
TVA SHAWNEE FOSSIL PLANT	MCCRACKEN	6,7,8	0	0	26.0 MGD avg 001	1	1
"	"	others	13000	64500		535	108
USCOE WOLF CREEK POWER PLT	RUSSELL		105		no process ww		
WESTERN KY ENERGY CORP COLEMAN	HANCOCK		13000	64500	no process ww		
WESTERN KY ENERGY CORP REID GR	WEBSTER		590	5100	69.8 MGD avg 001	16	3
WESTERN KY ENERGY CORP WILSON	OHIO	1,2,9	551	3893	0.84 MGD avg 001	999	141
"	"	3	0	0		1	1

The outfall mean annual flow rate, which is reported in Millions of Gallons per Day (MGD), was converted to cubic feet per second (cfs) by multiplying by 1.547 cfs/MGD.

The dilution factor was estimated by using one-third of the harmonic mean (to represent partial mixing) and dividing it by the average annual flow rate of the outfall. The use of one-third of the flow rate is based on the procedure for estimating a mixing zone as described in 401 KAR 5:029 Section 4(6). The resulting value is an estimate of the average dilution that occurs when the outfall empties into the receiving stream and undergoes partial mixing. Because there is a zone where dilution has not occurred, the risk screening will also be done on the undiluted outfall, as well.

The harmonic means were used for calculating the dilution factor for human health screening. Where the flow of the receiving stream is zero, the dilution factor is 1.0 indicating that there is no dilution. For outfalls where the outfall and the receiving stream are similar in magnitude, the flow of the outfall may contribute significantly to the total flow of the receiving stream. Therefore, for outfalls where the dilution factor that was calculated using these procedures was less than ten, then the flow of the outfall was added into the flow of the receiving stream. For example, for Kentucky Utilities' E.W. Brown Generating Station, the calculated dilution factor for the harmonic mean flow of the receiving stream would be three. The ratio between the flow rate of the outfall and the stream is 1:3. A dilution factor of four indicates that the outfall flow would make up 25 percent of the total flow, and the concentration after partial mixing into the receiving stream would be ¼ that of the outfall. All dilution factors were rounded to a whole number.

To estimate the concentration of contaminants in the receiving water body, the concentration in the outfall was divided by the dilution factor listed in Table 2. Those concentrations and the undiluted outfall were compared to human health metrics. Ecological impacts of the outfalls are evaluated in Appendix E using the 7Q10 in place of the harmonic mean.

<u>Risk Screening</u>

It was assumed that two types of receptor could potentially be exposed to surface water bodies. The first receptor would use the surface water as a domestic water source without prior treament. The domestic water user is assumed to be exposed via ingestion of tap water, except for mercury, which used ingestion and inhalation. The second human health receptor is a recreational user of the water body (*e.g.*, fishing, wading, and swimming). The recreational user is assumed to be exposed via incidental ingestion of water and dermal contact. For carcinogenic chemicals, the receptor would be exposed from age one to 30 years. Noncarcinogenic chemicals were assessed for a child receptor. These assumptions were used to be protective of sensitive subpopulations. The domestic water source and recreational receptors were calculated using risk assessment methodology developed for environmental decision-making. The methods are described in detail in the appendix for Derivation of Human Health Screening Values (Appendix G).

The surface water was also compared to the Maximum Contaminant Level (MCL) listed in National Primary Drinking Water Standards (U.S. EPA, 2001). A Maximum Contaminant Level is the concentration in tap water that must be met to comply with drinking water standards and is considered to be a relevant standard for comparison in this study. The human health screening values are listed in Table 3. The basis of the screening value is listed as (c) for carcinogenic effects, and (nc) for noncarcinogenic effects.

Table 3. Human Health Screening Values for Surface Water Outfalls.

Parameter	Residential Tap Water (μg/L)	Recreational Use (μg/L)	MCL (μg/L)
Arsenic	0.032 (c)	2.7 (c)	50
Cadmium	0.0034 (c)	400 (nc)	5
Chromium	0.0005 (c)	4000 (nc)	100
Copper	370 (nc)	29000 (nc)	1300
Iron	3000 (nc)	24000 (nc)	---
Lead	0.001 (nc)	0.08 (nc)	15
Manganese	0.054 (nc)	19000 (nc)	---
Mercury	0.3 (nc)	79 (nc)	2
Nickel	200 (nc)	16000 (nc)	---
Selenium	50 (nc)	4000 (nc)	50
Silver	50 (nc)	4000 (nc)	---
Zinc	3000 (nc)	24000 (nc)	---
PCBs	0.0074 (c)	0.031 (c)	0.5

Results

Tables 4 and 5 summarize the results of the human health screening evaluation for the average outfall concentrations without and with a dilution factor, respectively. Tables 6 and 7 contain the screening results for the maximum undiluted and diluted outfall values for the monitoring period. Tables 4 through 7 also include the frequency of detection of the contaminants.

The threshold that is used for eliminating chemicals that are detected infrequently is ten percent. Lead average values and total arsenic, mercury, and polychlorinated biphenyls (PCBs) for the maximum values had less than ten percent frequency of detection. The remaining chemicals are considered to be Chemicals of Potential Concern (COPCs). The shaded cells in the tables indicate the chemicals that exceed the screening value for tap water, recreational use, or the MCL.

The average values for six COPCs (arsenic, chromium, copper, iron, manganese, and PCBs) exceed the tap water screening value in the outfall. Four chemicals exceeded the tap water screening value after dilution (with copper and PCBs dropping out), although total iron exceeded it only once out of 77 samples. Arsenic and PCBs were the only COPCs that exceeded the recreational value when screening the average values. Arsenic was the only contaminant that exceeded it's MCL before dilution. None of the average values exceeded their respective MCLs after dilution.

Table 6 and 7 show the screening results of the maximum values for the outfalls. The maximum value is often used for screening purposes to identify which contaminants are carried through into a baseline risk assessment. Eight COPCs (arsenic, cadmium, chromium, copper, iron, lead, manganese, and zinc) had exceedances of the screening value for residential use of tap water. Five exceeded the screening value after dilution, with cadmium, copper, total iron, and total zinc dropping out after dilution. Four COPCs exceeded the recreational screening value in the outfall (arsenic, copper, lead, and zinc), and only total recoverable arsenic and total recoverable lead exceeded the recreational values after dilution. Three of the COPCs had exceedances of the MCLs in the undiluted outfalls: total recoverable arsenic (3 / 32), total copper (12 / 95), and total lead (1 / 64). All COPCs were below the MCL after partial mixing. It should be noted that the residential and recreational risk-based numbers for lead were based on organic lead (tetraethyl lead) toxicity values. If the lead that was detected in the outfalls was inorganic, the toxicity would be lower and the screening value would be higher.

Table 4. Frequency of Detection and Exceedance of Criteria for Average Parameter Values without Dilution.

Parameter	Frequency of Detection	Residential Tap Water	Recreational Use	MCL
Arsenic	22 / 32	32 / 32	16 / 32	3 / 32
Cadmium	0 / 0	0 / 0	0 / 0	0 / 0
Chromium	76 / 77	77 / 77	0 / 77	0 / 77
Copper, Total	14 / 19	3 / 19	0 / 19	0 / 19
Copper, Total Recoverable	27 / 60	1 / 60	0 / 60	0 / 60
Iron, Total	65 / 67	0 / 67	0 / 67	---
Iron, Total Recoverable	71 / 77	7 / 77	0 / 77	---
Lead	3 / 36	36 / 36	36 / 36	0 / 36
Manganese, Total	42 / 45	45 / 45	0 / 45	---
Manganese, Total Recoverable	23 / 23	23 / 23	0 / 23	---
Mercury	0 / 0	0 / 0	0 / 0	0 / 0
Nickel	24 / 30	0 / 30	0 / 30	---
Selenium	16/31	0 / 31	0 / 31	0 / 31
Silver	0 / 0	0 / 0	0 / 0	0 / 0
Zinc, Total	104/104	0 / 104	0 / 104	---
Zinc, Total Recoverable	27 / 34	0 / 34	0 / 34	---
PCBs	3 / 16	16 / 16	3 / 16	0 / 16

Table 5. Frequency of Detection and Exceedance of Criteria for Average Parameter Values after Dilution.

Parameter	Frequency of Detection	Residential Tap Water	Recreational Use	MCL
Arsenic	22 / 32	22 / 32	10 / 32	0 / 32
Cadmium	0 / 0	0 / 0	0 / 0	0 / 0
Chromium	76 / 77	77 / 77	0 / 77	0 / 77
Copper, Total	14 / 19	* 0 / 19	* 0 / 19	* 0 / 19
Copper, Total Recoverable	27 / 60	* 0 / 60	* 0 / 60	* 0 / 60
Iron, Total	65 / 67	* 0 / 67	* 0 / 67	---
Iron, Total Recoverable	71 / 77	* 1 / 77	* 0 / 77	---
Lead	3 / 36	36 / 36	22 / 36	0 / 36
Manganese, Total	42 / 45	35 / 45	0 / 45	---
Manganese, Total Recoverable	23 / 23	23 / 23	0 / 23	---
Mercury	0 / 0	0 / 0	0 / 0	0 / 0
Nickel	24 / 30	0 / 30	0 / 30	---
Selenium	16/31	0 / 31	0 / 31	0 / 31
Silver	0 / 0	0 / 0	0 / 0	0 / 0
Zinc, Total	104/104	0 / 104	0 / 104	---
Zinc, Total Recoverable	27 / 34	0 / 34	0 / 34	---
PCBs	3 / 16	* 0 / 16	* 0 / 16	* 0 / 16

* There were two facilities that had no outfall flow data listed, LG&E Trimble Station had iron and the maximum detect of copper; the TVA hydro plant had all of the PCB values.

Table 6. Frequency of Detection and Exceedance of Criteria for Maximum Parameter Values without Dilution.

Parameter	Frequency of Detection	Residential Tap Water	Recreational Use	MCL
Arsenic, Total	2 / 64	64 / 64	4 / 64	0 / 64
Arsenic, Total Recoverable	23 / 32	32 / 32	16 / 32	3 / 32
Cadmium	31 / 64	64 / 64	0 / 64	0 / 64
Chromium	101 / 141	141 / 141	0 / 141	0 / 141
Copper, Total	84 / 95	16 / 95	4 / 95	12 / 95
Copper, Total Recoverable	29 / 60	1 / 60	0 / 60	0 / 60
Iron, Total	123 / 129	10 / 129	0 / 129	---
Iron, Total Recoverable	75 / 77	9 / 77	0 / 77	---
Lead, Total	14 / 64	64 / 64	64 / 64	1 / 64
Lead, Total Recoverable	31 / 36	36 / 36	36 / 36	0 / 36
Manganese, Total	106 / 109	109 / 109	0 / 109	---
Manganese, Total Recoverable	23 / 23	23 / 23	0 / 23	---
Mercury	0 / 64	0 / 64	0 / 64	0 / 64
Nickel	24 / 30	0 / 30	0 / 30	0 / 30
Selenium, Total	14 / 64	0 / 64	0 / 64	0 / 64
Selenium, Total Recoverable	16 / 31	0 / 31	0 / 31	0 / 31
Silver	12 / 64	0 / 64	0 / 64	0 / 64
Zinc, Total	116 / 180	13 / 180	12 / 180	---
Zinc, Total Recoverable	28 / 34	0 / 34	0 / 34	---
PCBs	3 / 48	48 / 48	35 / 48	0 / 48

Table 7. Frequency of Detection and Exceedance of Criteria for Maximum Parameter Values after Dilution.

Parameter	Frequency of Detection	Residential Tap Water	Recreational Use	MCL
Arsenic, Total	2 / 64	1 / 64	0 / 64	0 / 64
Arsenic, Total Recoverable	23 / 32	22 / 32	10 / 32	0 / 32
Cadmium	31 / 64	0 / 64	0 / 64	0 / 64
Chromium	101 / 141	102 / 141	0 / 141	0 / 141
Copper, Total	84 / 95	* 0 / 95	* 0 / 95	* 0 / 95
Copper, Total Recoverable	29 / 60	* 0 / 60	* 0 / 60	* 0 / 60
Iron, Total	123 / 129	* 0 / 129	* 0 / 129	---
Iron, Total Recoverable	75 / 77	* 1 / 77	* 0 / 77	---
Lead, Total	14 / 64	64 / 64	0 / 64	0 / 64
Lead, Total Recoverable	31 / 36	36 / 36	22 / 36	0 / 36
Manganese, Total	106 / 109	69 / 109	0 / 109	---
Manganese, Total Recoverable	23 / 23	23 / 23	0 / 23	---
Mercury	0 / 64	0 / 64	0 / 64	0 / 64
Nickel	24 / 30	0 / 30	0 / 30	0 / 30
Selenium, Total	14 / 64	0 / 64	0 / 64	0 / 64
Selenium, Total Recoverable	16 / 31	0 / 31	0 / 31	0 / 31
Silver	12 / 64	0 / 64	0 / 64	0 / 64
Zinc, Total	116 / 180	0 / 180	0 / 180	---
Zinc, Total Recoverable	28 / 34	0 / 34	0 / 34	---
PCBs	3 / 48	* 32 / 48	* 0 / 48	* 0 / 48

* See note on Table 6. Two facilities had no flow data listed in the outfalls.

The U.S. EPA has recently announced that they will be lowering the MCL for arsenic from 50 µg/L to 10 µg/L. All water systems must be in compliance with the new rule by January 2006. This change would have some affect on the results of Tables 4 through 7. Table 8 shows the comparison of the exceedances for both the old and new MCL. There would be a higher number of exceedances if the MCL were lower, but the impact would be minor.

Table 8. Comparison of the Number of Exceedances for Arsenic of the old and new MCL

Scenario	**50 µg/L (old)**	**10 µg/L (new)**
Average Value before Dilution	3 / 32	5 / 32
Average Value after Dilution	0 / 32	4 / 32
Maximum Total Arsenic Value before Dilution	0 / 64	0 / 64
Maximum Total Arsenic Value after Dilution	0 / 64	0 / 64
Maximum Total Recoverable Value before Dilution	3 / 32	5 / 32
Maximum Total Recoverable Value after Dilution	0 / 32	4 / 32

<u>Uncertainties</u>

The submitted data were limited in scope. Semivolatiles (SVOCs) and volatiles (VOCs) were not reported as part of the monitoring program. Metals were limited to 12 constituents.

Two facilities were listed as 'no process wastewater' (LG&E Trimble Station and TVA Hydro). Those facilities did have contaminants in their outfall, however. Because no flow rate of the outfalls were available, the dilution factor could not be calculated for those facilities.

The outfall was assumed to be diluted by the receiving stream. If exposures were to occur chronically to outfalls with less dilution or undiluted, the risk would be higher than those detailed in Tables 5 and 7. Because of the limited mixing that was assumed, exposures to the streams outside of the initial mixing zone would be lower.

Each individual outfall was evaluated individually. Cumulative impacts from multiple outfalls from the same facility could not be evaluated in this study.

When calculating dilution the mean flow was often given for one outfall for the facility. This flow rate was extrapolated to the other outfalls for the facility.

Twelve facilities reported metals data for 1997-2001. Several had only a couple of reporting events. This may underestimate the potential risks associated with the outfalls if contaminants were not analyzed or data were not reported (*e.g.*, semivolatile organic chemicals, and volatile organic chemicals).

Use of a dilution factor assumes that the concentration in the outfall is a result of contamination and that the compound is not present in the receiving stream. Since some of the metals may be present naturally in the stream (and in the water withdrawn for facility use), there may not be any dilution of the outfall concentration.

Each of the COPCs was screened individually. The metals may act additively with each other or with contaminants already present in the receiving stream if they have similar target organs. This could be dealt with by screening with one-tenth of the screening value to account for additivity and samples could be taken of the receiving streams downgradient of the outfalls to evaluate potential exposure concentrations. Downgradient samples could also be used to investigate cumulative impacts of the entire facility.

This study of surface water impacts from power plants does not take into account the potential nitrogen loading that may occur from ammonia as part of the process of Selective Catalytic Reduction (SCR) systems. Many of the existing plants are installing these units to lower NO_x emissions. As a common component of the SCR technology, ammonia is injected into the SCR system and may result in ammonia emissions and may also be partially bound in the ash. There is the potential for runoff from the ash ponds and process water to have increased concentrations of ammonia as a result of the coal-fired power plants installing SCR units. Increased loading of ammonia to surface water can result in human health and ecological effects.

Most of the proposed plants are still early in the permitting process, so potential surface water impacts of the individual plants have not been evaluated at this time. It is assumed that the plants would have similar outfall characteristics and similar screening results when compared to existing facilities that have the same fuel type. In the case of those proposed plants that are additional units for existing facilities, the increased capacity has the potential to increase the parameter values in their outfalls or even increase the number of outfalls.

This screening evaluation was conducted using average flow rates of the outfalls and receiving streams. In general, this approach is appropriate for estimating chronic exposures. The concentrations likely vary throughout the year with periods where the outfall and stream may be higher or lower in flow. Long periods of low stream flow such as during drought conditions would result in higher exposure concentrations and could result in higher risks to exposed populations.

Finally, exceeding the residential and recreational values indicates that the concentrations that are reported have the potential to impact sensitive subpopulations based on the theoretical receptor and the protective nature of the exposure assumptions. Actual exposures that occur are likely to be lower.

Conclusions

The outfalls associated with power plants are the result of process-related activities, ash pond outfalls, and facility run-off. The DMR data were used to evaluate potential impacts of surface water outfalls. Much of the data submitted are for parameters that are of limited use for a human toxicological evaluation. Eliminating those parameters from further human-health evaluation resulted in a limited dataset.

More than one-half of the parameters in the undiluted outfalls had exceedances of risk-based residential tap water screening values. Recreational use of the water before dilution had exceedances for one-third of the parameters' maximum values and arsenic, lead and PCBs for the average value. When the undiluted values were screened against the MCL, arsenic for the average parameters, and arsenic and copper for the maximum values had exceedances. Lead exceeded the MCL in only one sample out of 64 maximum values. Recreational use of the water after partial mixing had few exceedances, and none of the parameters exceeded the MCL after dilution for average and maximum values. If the new arsenic MCL were used, there would be a small increase in the number of exceedances of the MCL.

References

U.S. EPA. 2001. National Primary Drinking Water Standards. Office of Water. March 2001. EPA 816-F-01-007. 4 pp.

Appendix D

Ash Landfill Risk Evaluation

Prepared by:

Kentucky Department for Environmental Protection

Division of Environmental Services

Risk Assessment Branch

December 17, 2001

Introduction

On June 19, 2001, Governor Paul Patton issued a Moratorium on Permits for New Power Plants. The Natural Resources and Environmental Protection Cabinet was directed to study the potential environmental impacts from increased generating capacity. This assessment of surface water outfalls was conducted in conjunction with the study being conducted by the Natural Resources and Environmental Protection Cabinet.

Coal burning utilities comprise the majority of existing power plants. A 1994 study indicated that 68 percent of the total megawatts generated nationally are produced at coal burning facilities (U.S. EPA, 1998). The current capacity of Kentucky's power plants is about 18,000 megawatts, with 89 percent produced by coal burning power plants. About ten percent of every ton of coal ends up as ash (Stamper, 2001). There are over 40 million tons of coal burned every year in Kentucky power plants. The burning of coal results in ash left in the combustion chamber, in baghouses and in other particulate control equipment that is designed to capture particulates prior to leaving the stack. With the use of scrubbers, ash may also end up combined with limestone and other additives such as ammonia that are used to reduce sulfur emissions and ozone-producing gases, respectively.

Twenty-two of Kentucky's 34 existing power plants burn coal. Facilities burning coal must either dispose of the ash or find a beneficial re-use of the material. Some ash is used in concrete production; scrubber waste can be used as synthetic gypsum (calcium sulfite) and made into drywall. About one-half of the power plants currently operating in Kentucky have a landfill for disposal. The landfills associated with power plants contain ash from power plants and may also contain partially combusted coal and waste associated with coal production and washing.

There are 12 special waste permits for the existing power plants with three facilities permitted under one permit (Green, Henderson 2, and Reid). The coal combustion byproducts are permitted as a special waste. The facilities are required to monitor for metals and inorganics for two years (401 KAR 45:160 Section 7(2)(a)). Also, monitoring is required semiannually for groundwater parameters (chloride, chemical oxygen demand, total dissolved solids, total organic carbon, specific conductance, pH, and copper) as described in 401 KAR 45:160 Section 8(2)(a).

Selection of Surrogate Landfill

A surrogate landfill was selected to estimate potential environmental impacts from ash landfills. The Division of Waste Management evaluated the existing landfills to select a surrogate. The landfill for the Louisville Gas and Electric (LG&E) Mill Creek Station was selected as the landfill that would be evaluated. There are two facilities that have a higher design capacity, but one is a surface impoundment permitted by the Division of Water and therefore does not have a solid waste permit. The other larger facility has a landfill that does not contain only fly ash. Because the intent of the study is to evaluate the potential impact from fly ash disposal, the Mill Creek Station was selected. Mill Creek also has recent data for metals in monitoring wells.

The Mill Creek Station is a coal burning facility with four units. The total design capacity of all units is 1717 megawatts. It is the fourth largest plant in Kentucky (by generating capacity). The facility is located in southwest Jefferson County on the Ohio River. The Solid Waste Permit number is SW-056-00029. The station uses about 3.4 million tons of coal per year and produces 350,000 tons of ash per year, 80-85 percent of which is fly ash. The ash is mixed with scrubber sludge and placed in the landfill. The two landfills at Mill Creek Station cover 170 acres and are unlined (LG&E, 1997). The landfill's capacity is higher than the average landfill (100 acres) at the power plants.

Data Collection and Evaluation

The groundwater monitoring reports and a Groundwater Monitoring Plan (LG&E, 1997) were obtained from the Division of Waste Management file room and the data were evaluated for completeness. The Groundwater Monitoring Plan contained historical quarterly monitoring data from 1981 to 1996 in Appendix B. The last five years were selected (1991 – 1995 plus one date in 1996) for comparison to risk-based concentration in water and MCLs. The data are presented in Table 1 for the metals.

Table 1. 1991-1996 Groundwater Data from Mill Creek Station (mg/L).

Date	Well [1]	Arsenic	Barium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver
5/13/91	MW-1	0.006	0.05	<0.001	0.03	0.003	0.0001	0.007	<0.01
4/28/92	MW-1	0.004	0.06	<0.001	0.02	<0.001	<0.0002	<0.005	0.01
9/23/92	MW-1	0.006	<0.05	<0.001	<0.01	0.002	0.0002	<0.005	0.01
5/17/93	MW-1	<0.001	0.08	<0.001	0.04	<0.001	<0.0002	<0.005	0.03
8/30/93	MW-1	0.008	<0.05	<0.001	<0.01	0.002	0.0002	0.0025	0.01
8/3/94	MW-1	<0.001	<0.05	<0.001	<0.01	0.045	<0.0002	<0.005	<0.01
11/22/95	MW-1	0.005	<0.05	<0.001	0.01	<0.001	<0.0002	<0.005	<0.01
5/13/91	MW-2	0.013	0.07	<0.001	0.03	0.008	<0.0002	0.005	<0.01
4/28/92	MW-2	0.014	0.08	<0.001	0.02	<0.001	<0.0002	<0.005	0.01
9/22/92	MW-2	0.018	0.06	<0.001	0.01	<0.001	<0.0002	<0.005	<0.01
5/17/93	MW-2	0.013	0.09	<0.001	0.03	<0.001	<0.0002	<0.005	0.03
8/30/93	MW-2	0.015	0.06	<0.001	<0.01	0.002	0.0002	<0.005	<0.01
8/3/94	MW-2	0.014	<0.05	<0.001	<0.01	0.003	<0.0002	<0.005	<0.01
11/22/95	MW-2	0.015	0.06	<0.001	<0.01	0.002	<0.0002	<0.005	<0.01
5/13/91	MW-3	0.006	<0.05	0.001	0.03	0.009	<0.0002	<0.005	<0.01
4/28/92	MW-3	<0.001	0.05	<0.001	0.03	<0.001	<0.0002	<0.005	0.01
9/23/92	MW-3	0.005	<0.05	<0.001	<0.01	<0.001	<0.0002	<0.005	<0.01
5/17/93	MW-3	<0.001	0.06	<0.001	0.04	<0.001	0.0005	<0.005	0.02
8/30/93	MW-3	0.008	<0.05	<0.001	0.01	0.002	<0.0002	<0.005	<0.01
8/3/94	MW-3	<0.001	<0.05	<0.001	<0.01	0.013	<0.0002	<0.005	<0.01
11/22/95	MW-3	0.002	<0.05	<0.001	<0.01	0.003	<0.0002	<0.005	<0.01
5/13/91	MW-4	0.007	<0.05	0.001	0.03	0.008	<0.0002	<0.005	<0.01
4/28/92	MW-4	0.003	<0.05	<0.001	0.02	<0.001	<0.0002	<0.005	0.01
9/23/92	MW-4	0.004	<0.05	<0.001	<0.01	<0.001	0.0002	<0.005	<0.01
5/17/93	MW-4	<0.001	0.06	<0.001	0.03	<0.001	<0.0002	<0.005	0.02
8/30/93	MW-4	0.005	<0.05	<0.001	0.01	0.002	0.0002	<0.005	<0.01
8/3/94	MW-4	<0.001	<0.05	<0.001	<0.01	0.003	<0.0002	<0.005	<0.01
11/22/95	MW-4	0.005	<0.05	<0.001	0.01	<0.001	<0.0002	<0.005	<0.01
5/13/91	MW-5	0.005	0.06	0.001	0.03	0.011	<0.0002	<0.005	<0.01
4/28/92	MW-5	0.007	0.08	<0.001	0.02	<0.001	<0.0002	<0.005	0.02
9/23/92	MW-5	0.009	0.06	<0.001	<0.01	<0.001	<0.0002	<0.005	<0.01
5/28/93	MW-5	<0.001	0.09	<0.001	0.02	0.006	0.0003	0.012	<0.01
8/31/93	MW-5	0.01	0.05	<0.001	<0.01	0.002	0.0002	<0.005	<0.01
8/3/94	MW-5	0.005	<0.05	<0.001	<0.01	0.003	<0.0002	<0.005	<0.01
11/22/95	MW-5	0.006	0.06	<0.001	0.01	<0.001	<0.0002	<0.005	<0.01
5/13/91	MW-6	0.005	0.06	0.001	0.03	0.008	<0.0002	<0.005	<0.01
4/28/92	MW-6	0.006	0.08	<0.001	0.02	0.002	<0.0002	<0.005	<0.01
9/23/92	MW-6	0.007	0.06	<0.001	<0.01	<0.001	<0.0002	0.009	<0.01
5/17/93	MW-6	<0.001	0.09	<0.001	0.04	<0.001	<0.0002	<0.005	0.03
8/31/93	MW-6	0.009	0.06	<0.001	0.01	0.001	<0.0002	<0.005	<0.01
8/3/94	MW-6	0.004	<0.05	<0.001	<0.01	0.003	<0.0002	<0.005	<0.01
11/22/95	MW-6	0.006	0.11	<0.001	<0.01	0.003	0.001	<0.005	<0.01
5/13/91	PW-1	0.01	0.24	<0.001	0.02	0.006	<0.0002	<0.005	<0.01
4/28/92	PW-1	0.015	0.23	<0.001	0.03	<0.001	<0.0002	<0.005	0.02
9/22/92	PW-1	0.018	0.23	<0.001	<0.01	<0.001	<0.0002	<0.005	<0.01
5/17/93	PW-1	0.015	0.17	<0.001	0.04	<0.001	<0.0002	<0.005	<0.01
8/30/93	PW-1	0.02	0.17	<0.001	<0.01	0.002	0.0002	<0.005	<0.01
8/3/94	PW-1	0.014	<0.05	<0.001	<0.01	0.002	<0.0002	<0.005	<0.01
11/22/95	PW-1	0.014	0.13	<0.001	<0.01	0.002	<0.0002	<0.005	<0.01
5/13/91	PW-2	0.007	0.34	<0.001	0.03	0.005	<0.0002	<0.005	<0.01
4/28/92	PW-2	0.007	0.21	<0.001	0.02	<0.001	<0.0002	<0.005	0.01
9/22/92	PW-2	0.004	0.09	<0.001	<0.01	<0.001	<0.0002	<0.005	<0.01
5/17/93	PW-2	0.01	0.22	<0.001	0.04	<0.001	<0.0002	<0.005	0.02
8/30/93	PW-2	0.013	0.19	<0.001	<0.01	0.003	0.0002	<0.005	<0.01
11/22/95	PW-2	0.007	0.15	<0.001	0.01	0.001	<0.0002	<0.005	<0.01
5/13/91	PW-3	0.003	0.09	<0.001	0.03	0.008	<0.0002	<0.005	<0.01
4/28/92	PW-3	0.015	0.32	<0.001	0.02	0.002	<0.0002	<0.005	0.02
9/22/92	PW-3	0.022	0.3	<0.001	0.01	<0.001	<0.0002	<0.005	<0.01
5/17/93	PW-3	0.01	0.09	<0.001	0.04	<0.001	<0.0002	<0.005	0.03
8/30/93	PW-3	0.018	0.28	<0.001	<0.01	0.003	0.0002	<0.005	<0.01
8/3/94	PW-3	0.013	<0.05	<0.001	0.01	0.025	<0.0002	<0.005	<0.01
11/22/95	PW-3	0.009	0.26	<0.001	<0.01	0.0001	<0.0002	<0.005	<0.01

[1] Monitoring well (mw) and production well (pw)

Monitoring wells MW-1, MW-3, and MW-5 are upgradient of the landfills and MW-2, MW-4, MW-6, and production wells PW-1, PW-2, and PW-3 are downgradient of the landfills. The data were transformed for risk evaluation by converting nondetects to one-half the detection limit. Since a nondetect is assumed to have a concentration somewhere between zero and the detection limit, one-half was used. The data were also segregated into upgradient and downgradient wells. MTCA Stat Site Module V2.1 was used to analyze the data. The distribution for each dataset was determined and the 95% Upper Confidence Limit (UCL) of the mean was calculated for each contaminant in the upgradient and downgradient wells. The 95% UCL is the value that, when calculated repeatedly for randomly drawn subsets of site data, equals or exceeds the true mean 95 percent of the time.

Risk Screening

For screening purposes, it is assumed that the groundwater in the monitoring wells and production wells is a potential source for domestic use. A residential receptor was assumed to be exposed to the groundwater. This assumption, though unlikely, assumes that there is no treatment prior to use by the receptor. The wells do represent some dilution of the initial leachate, and further dilution is possible before an actual receptor could be exposed. The wells represent the groundwater quality at the location of the well. The calculation of a screening level for a residential receptor is described in more detail in Appendix G. For carcinogenic substances, a residential receptor was assumed to be exposed via ingestion of tap water from age 1 to 30 years. Noncarcinogenic substances were evaluated for a child from ages one through six. A receptor could also be exposed to a landfill via incidental ingestion and inhalation of soil or dust from the landfill. A recreational receptor could be exposed via wading or swimming in a surface water body that receives surface water runoff from the landfill. The exposure to dust and soil could not be evaluated in this assessment, and the surface water outfalls are evaluated in Appendix C, Surface Water Outfall Risk Evaluation.

Results

Table 2 presents the screening values and Maximum Contaminant Levels (MCLs) for each metal. An MCL is the concentration in tap water that must be met to comply with drinking water standards and is considered to be a relevant standard for comparison in this study. The MCLs were obtained from U.S. EPA (2001). Tables 3 and 4 present the transformed data for monitoring and production wells at the Mill Creek Station landfill at upgradient and downgradient locations, respectively. The 95% UCL for each metal is presented for both upgradient and down gradient wells. The data were initially evaluated for frequency of detection. Selenium and cadmium were both detected in less than 10% of samples. Of the remaining 6 metals, all but mercury and silver exceeded the risk-based screening number for the individual contaminant. The downgradient wells were then compared to the upgradient wells. The 95% UCL of the downgradient wells was two times higher for arsenic than the upgradient wells and three times higher for barium. All other metals were at or below upgradient levels. All data were compared to the MCL. None of the 95% UCLs for the eight metals exceeded the MCL for domestic water use. Shaded cells indicate that the screening value was exceeded for that contaminant.

Table 2. Risk Based Concentrations and MCLs for Metals in Groundwater (mg/L).

Metal	Risk-based Screening Value	MCL
Arsenic	3.2E-05	0.05
Barium	0.00055	2
Cadmium	3.4E-06	0.005
Chromium	5.1E-07	0.1
Lead	1.0E-06	0.015
Mercury	0.0003	0.002
Selenium	0.05	0.05
Silver	0.05	0.1

Table 3. Upgradient Wells at Mill Creek Station.

Date	Monitoring Well	Arsenic	Barium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver
8/30/93	MW-1	0.008	0.025	0.0005	0.005	0.002	0.0002	0.0025	0.01
5/13/91	MW-1	0.006	0.05	0.0005	0.03	0.003	0.0001	0.007	0.005
9/23/92	MW-1	0.006	0.025	0.0005	0.005	0.002	0.0002	0.0025	0.01
11/22/95	MW-1	0.005	0.025	0.0005	0.01	0.0005	0.0001	0.0025	0.005
4/28/92	MW-1	0.004	0.06	0.0005	0.02	0.0005	0.0001	0.0025	0.01
5/17/93	MW-1	0.0005	0.08	0.0005	0.04	0.0005	0.0001	0.0025	0.03
8/3/94	MW-1	0.0005	0.025	0.0005	0.005	0.045	0.0001	0.0025	0.005
8/30/93	MW-3	0.008	0.025	0.0005	0.01	0.002	0.0001	0.0025	0.005
5/13/91	MW-3	0.006	0.025	0.001	0.03	0.009	0.0001	0.0025	0.005
9/23/92	MW-3	0.005	0.025	0.0005	0.005	0.0005	0.0001	0.0025	0.005
11/22/95	MW-3	0.002	0.025	0.0005	0.005	0.003	0.0001	0.0025	0.005
4/28/92	MW-3	0.0005	0.05	0.0005	0.03	0.0005	0.0001	0.0025	0.01
5/17/93	MW-3	0.0005	0.06	0.0005	0.04	0.0005	0.0005	0.0025	0.02
8/3/94	MW-3	0.0005	0.025	0.0005	0.005	0.013	0.0001	0.0025	0.005
8/31/93	MW-5	0.01	0.05	0.0005	0.005	0.002	0.0002	0.0025	0.005
9/23/92	MW-5	0.009	0.06	0.0005	0.005	0.0005	0.0001	0.0025	0.005
4/28/92	MW-5	0.007	0.08	0.0005	0.02	0.0005	0.0001	0.0025	0.02
11/22/95	MW-5	0.006	0.06	0.0005	0.01	0.0005	0.0001	0.0025	0.005
5/13/91	MW-5	0.005	0.06	0.001	0.03	0.011	0.0001	0.0025	0.005
8/3/94	MW-5	0.005	0.025	0.0005	0.005	0.003	0.0001	0.0025	0.005
5/28/93	MW-5	0.0005	0.09	0.0005	0.02	0.006	0.0003	0.012	0.005
	Distribution	normal	lognormal	lognormal	lognormal	lognormal	lognormal	lognormal	lognormal
	95% UCL	0.0056	0.056	0.00059	0.0254	0.01186	0.00017	0.0036	0.0107
Risk-based Concentration		0.000032	0.00055	0.0000034	5.1E-07	0.000001	0.0003	0.05	0.05
	MCL	0.05	2	0.005	0.1	0.015	0.002	0.05	0.1

Table 4. Downgradient Wells at Mill Creek Station.

Date	Monitoring Well	Arsenic	Barium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver
9/22/92	MW-2	0.018	0.06	0.0005	0.01	0.0005	0.0001	0.0025	0.005
8/30/93	MW-2	0.015	0.06	0.0005	0.005	0.002	0.0002	0.0025	0.005
11/22/95	MW-2	0.015	0.06	0.0005	0.005	0.002	0.0001	0.0025	0.005
4/28/92	MW-2	0.014	0.08	0.0005	0.02	0.0005	0.0001	0.0025	0.01
8/3/94	MW-2	0.014	0.025	0.0005	0.005	0.003	0.0001	0.0025	0.005
5/13/91	MW-2	0.013	0.07	0.0005	0.03	0.008	0.0001	0.005	0.005
5/17/93	MW-2	0.013	0.09	0.0005	0.03	0.0005	0.0001	0.0025	0.03
5/13/91	MW-4	0.007	0.025	0.001	0.03	0.008	0.0001	0.0025	0.005
8/30/93	MW-4	0.005	0.025	0.0005	0.01	0.002	0.0002	0.0025	0.005
11/22/95	MW-4	0.005	0.025	0.0005	0.01	0.0005	0.0001	0.0025	0.005
9/23/92	MW-4	0.004	0.025	0.0005	0.005	0.0005	0.0002	0.0025	0.005
4/28/92	MW-4	0.003	0.025	0.0005	0.02	0.0005	0.0001	0.0025	0.01
5/17/93	MW-4	0.0005	0.06	0.0005	0.03	0.0005	0.0001	0.0025	0.02
8/3/94	MW-4	0.0005	0.025	0.0005	0.005	0.003	0.0001	0.0025	0.005
8/31/93	MW-6	0.009	0.06	0.0005	0.01	0.001	0.0001	0.0025	0.005
9/23/92	MW-6	0.007	0.06	0.0005	0.005	0.0005	0.0001	0.009	0.005
4/28/92	MW-6	0.006	0.08	0.0005	0.02	0.002	0.0001	0.0025	0.005
11/22/95	MW-6	0.006	0.11	0.0005	0.005	0.003	0.001	0.0025	0.005
5/13/91	MW-6	0.005	0.06	0.001	0.03	0.008	0.0001	0.0025	0.005
8/3/94	MW-6	0.004	0.025	0.0005	0.005	0.003	0.0001	0.0025	0.005
5/17/93	MW-6	0.0005	0.09	0.0005	0.04	0.0005	0.0001	0.0025	0.03
8/30/93	PW-1	0.02	0.17	0.0005	0.005	0.002	0.0002	0.0025	0.005
9/22/92	PW-1	0.018	0.23	0.0005	0.005	0.0005	0.0001	0.0025	0.005
4/28/92	PW-1	0.015	0.23	0.0005	0.03	0.0005	0.0001	0.0025	0.02
5/17/93	PW-1	0.015	0.17	0.0005	0.04	0.0005	0.0001	0.0025	0.005
8/3/94	PW-1	0.014	0.025	0.0005	0.005	0.002	0.0001	0.0025	0.005
11/22/95	PW-1	0.014	0.13	0.0005	0.005	0.002	0.0001	0.0025	0.005
5/13/91	PW-1	0.01	0.24	0.0005	0.02	0.006	0.0001	0.0025	0.005
8/30/93	PW-2	0.013	0.19	0.0005	0.005	0.003	0.0002	0.0025	0.005
5/17/93	PW-2	0.01	0.22	0.0005	0.04	0.0005	0.0001	0.0025	0.02
5/13/91	PW-2	0.007	0.34	0.0005	0.03	0.005	0.0001	0.0025	0.005
4/28/92	PW-2	0.007	0.21	0.0005	0.02	0.0005	0.0001	0.0025	0.01
11/22/95	PW-2	0.007	0.15	0.0005	0.01	0.001	0.0001	0.0025	0.005
9/22/92	PW-2	0.004	0.09	0.0005	0.005	0.0005	0.0001	0.0025	0.005
9/22/92	PW-3	0.022	0.3	0.0005	0.01	0.0005	0.0001	0.0025	0.005
8/30/93	PW-3	0.018	0.28	0.0005	0.005	0.003	0.0002	0.0025	0.005
4/28/92	PW-3	0.015	0.32	0.0005	0.02	0.002	0.0001	0.0025	0.02
8/3/94	PW-3	0.013	0.025	0.0005	0.01	0.025	0.0001	0.0025	0.005
5/17/93	PW-3	0.01	0.09	0.0005	0.04	0.0005	0.0001	0.0025	0.03
11/22/95	PW-3	0.009	0.26	0.0005	0.005	0.0001	0.0001	0.0025	0.005
5/13/91	PW-3	0.003	0.09	0.0005	0.03	0.008	0.0001	0.0025	0.005
	Distribution	normal	lognormal	lognormal	lognormal	lognormal	lognormal	lognormal	lognormal
	95% UCL	0.01145	0.17	0.000544	0.0221	0.0043	0.000145	0.00286	0.00996
	Risk-based Concentration	0.000032	0.00055	0.0000034	5.1E-07	0.000001	0.0003	0.05	0.05
	MCL	0.05	2	0.005	0.1	0.015	0.002	0.05	0.1

The U.S. EPA has recently announced that they will be lowering the MCL for arsenic from 50 µg/L to 10 µg/L. All water systems must be in compliance with the new rule by January 2006. No upgradient wells exceeded the new MCL, but 17 out of 41 (41%) downgradient wells exceeded to new MCL, with a maximum of 22 µg/L. The 95% UCL for the downgradient wells is slightly above the new MCL (11 µg/L).

Uncertainties

The data collected were limited in scope. Semivolatiles (SVOCs) and volatiles (VOCs) were not analyzed as part of the monitoring program. Metals were limited to eight constituents. Beryllium, copper, manganese, magnesium, and zinc were not a part of the sampling data during the selected period (1991-1996).

It was assumed that this facility would be representative of other facilities and that environmental impacts of other facilities would be similar to the Mill Creek Station. It is uncertain what impact the mixing of the fly ash with scrubber sludge to produce a product called "Pos-O-Tec" has on the leachability of contaminants from the ash. The mixture forms a concrete-like substance prior to being placed in the landfill. Ash at other landfills may not be as resistant to leaching thereby resulting in higher levels of contamination in groundwater.

This study of groundwater impacts from ash landfills does not take into account the nitrogen loading that is expected to occur from ammonia as part of the process of Selective Catalytic Reduction (SCR) systems. Many of the existing plants are installing these units to lower NO_x emissions. As a common component of the SCR technology, ammonia is injected into the SCR system and may result in ammonia emissions and may also be partially bound in the ash. Increased loading of ammonia to groundwater can result in human health and ecological effects.

This study also does not take into account the impact of a variety of beneficial reuses, such as highway base course and structural fill. Power plants are not required to obtain written permission from the state to conduct beneficial reuses and the state does not inspect these sites, or require environmental monitoring. The power plant is not required to provide the state with information such as location and type of beneficial reuse. There is insufficient data in the public record on which to base an assessment.

Finally, it was assumed that the groundwater that was sampled in the monitoring wells is a potential source for domestic use. The exposure assumptions that are incorporated in the screening values and exposure assessment are intended to protect the more sensitive receptor, and actual risks are likely to be less.

Conclusions

Arsenic and barium are the metals that were found frequently in the groundwater at levels above risk-based levels. They were also elevated above the levels found in upgradient wells. No metals exceeded their MCL in groundwater. When the MCL for arsenic is reduced from 50 µg/L to 10 µg/L, then the downgradient wells would have slightly exceeded the MCL (11 µg/L).

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Appendix E

Kentucky Power Plants:
Ecological Impacts Evaluation

Prepared by:

Kentucky Department for Environmental Protection

Division of Water

Water Quality Branch

December 17, 2001

APPENDIX E
ECOLOGICAL IMPACTS EVALUATION

INTRODUCTION

The Kentucky Department for Environmental Protection is responsible for maintaining the quality of land, air, and water resources. An integral part of this responsibility is to assess the ecological health of terrestrial and aquatic environments throughout the Commonwealth, and to determine impacts to these resources by the regulated community. The construction and operation of electric producing power plants can have both direct and indirect deleterious effects on terrestrial and aquatic biota and their habitats. While there are environmental impacts common to all power plants, there are distinct effects that are associated with each type of power plant (e.g., hydro, coal-fired, oil/gas fired). An analysis of the various forms of potential ecological impacts was conducted and the results are provided below.

EXISTING FACILITIES

<u>Water Quality</u>

Power plants withdraw and discharge considerable quantities of water. Water withdrawal (see Appendix F) may be used mainly for cooling, ash slurry transport, and other processes. Discharge of effluent is monitored under the Kentucky Pollutant Discharge and Elimination System (KPDES) program where an existing plant (e.g., TVA Paradise Fossil Plant) may have as many as 17 permitted outfalls. Of the 34 existing facilities, 26 have KPDES permits. Three facilities have a common permit: Green, Henderson 2, and Reid. Waterborne pollutants that may come into contact with ecological communities range from thermal discharge to a variety of metals, suspended solids, oil and grease, and in the case of sanitary facilities, pathogens, nutrients, chlorine, and oxygen-demanding wastes. Effluent limits are independently set for various pollutants based on current water quality standards and the flow regime of the receiving waterbody (low-flow [7Q10] and/or harmonic mean in cubic feet per second).

Chemical Data

A review of over 44,000 monitoring records (i.e., Discharge Monitoring Reports (DMRs)) submitted by power plants to the KPDES Branch (1997-2001) revealed several common parameters that were repeatedly exceeded. While many monitored effluents do not have set limits, Table 1 shows the susceptibility of power plants to have numeric violations of some parameters that do have specific concentration limits. For purposes of ecological assessment, numeric exceedences could translate into excessive loading of environmental stressors into waterbodies containing aquatic biota including but not limited to fish, shellfish, waterfowl, and invertebrate communities. Common violations among power plants in general, included: fecal coliform with 70 percent of the plants reporting at least one violation. (e.g., improperly operated sanitary plants can contribute to excessive loading of human waste products such as pathogenic bacteria, nutrients, and oxygen demanding material); total suspended solids (68%) (e.g. ash disposal areas and storm water runoff contributes to excessive sediment loading and turbidity in receiving streams); pH (45%) (e.g. both acidic and alkaline effluent from coal washing areas or ash fills reaches receiving waterbody); and Oil & Grease (32%) (e.g. turbomachinery, furnaces, other heavy equipment leak oil and grease that makes its way into streams and rivers).

Table 1. Susceptibility (as percent) of power plants to have KPDES permit exceedences (1997-2001).

Effluent Parameter	**% Of Plants with Numeric Violation**	**# of Plants with Monitoring Requirement**
Fecal Coliform	70%	10
Biological Oxygen Demand (BOD)	46%	16
Chlorine*	33%	21
Manganese	50%	2
Ammonia-Nitrogen	40%	5
Oil and Grease	32%	22
pH	45%	22
Settleable Solids	20%	5
Total Suspended Solids	68%	22
Temperature**	19%	21
Toxicity	22%	18
Zinc	11%	9

* Free Chlorine, Total Chlorine, or Chlorination violations

**Temperature ºF or ºC, or Temperature Difference

Despite the relatively high percentage of power plants reporting a numeric permit violation, the actual number of violations per parameter per facility is quite low. Table 2 shows the actual percentage of monitoring events that were in violation of KPDES limits. While many reported values exceeded less than one percent of the time, several plants had greater than ten percent exceedences for different parameters.

Table 2. Percent of numerical violations by sample event (1997-2001) for parameters with set concentration limits.

Facility Name	**Fecal Coliform**	**BOD**	**Chloride**	**Manganese**	**Ammonia**	**Oil & Grease**	**Diss. Oxygen**	**pH**	**% Intake of Flow**	**Settleable Solid**	**Suspended Solid**	**Temperature**	**Toxicity**	**Zinc**
CINCINNATI G & E EAST BEND											<1			
EAST KY POWER COOP COOPER	4	5			4			<1			<1	4	11	
EAST KY POWER COOP DALE								<1						
EAST KY POWER COOP SMITH											1			
EAST KY POWER COOP SPURLOCK			7	4						1	4			
HENDERSON POWER & LIGHT STA #1						9								
KY POWER CO BIG SANDY PLANT	4	4	1		2	2							39	
KY UTIL E W BROWN GEN STA			1					1			2			
KY UTIL GHENT GENERATING			<1											
KY UTIL GREEN RV GEN STA		1	4						4					
KY UTIL PINEVILLE GEN STA			2								4			
LOUISVILLE G & E CANE RUN STA	6		2								2			
LOUISVILLE G & E MILL CRK STA						2		1			3		9	
LOUISVILLE G & E PADDYS RUN STA												2		
OWENSBORO MUN UTIL SMITH STA	17	4				2		1			25			
TVA KY HYDRO PLANT											6			
TVA PARADISE FOSSIL PLANT											1	4	5	
TVA SHAWNEE FOSSIL PLANT						1		<1				1		
USCOE WOLF CREEK POWER PLANT		1	2		1	18		3			<1			
WESTERN KY ENERGY COLEMAN	12						50	1			<1			
WESTERN KY ENERGY CORP REID	13							7			2			
WESTERN KY ENERGY CORP WILSON	6	4				2		<1			2			6

Parameters listed in KPDES Discharge Monitoring Reports that do not have set limits are also of concern. Many of these monitored elements are heavy metals such as cadmium, copper, mercury, etc. Fly ash landfills and ponds are the predominant source of these chemicals. With regard to ecological studies of fly ash discharges, Forbes et al. (1981) observed decreased aquatic insect abundance below a Wisconsin pond, which was attributed to a combination of low food quality and direct chemical effects. In South Carolina, a long-term exposure to fly ash discharge was reported to contribute to reductions in fish and invertebrate communities (Guthrie and Cherry, 1976). However, Van Hassel and Wood (1984) found that elevated metals (e.g., arsenic, copper, and lead) below ash ponds did not alter benthic invertebrate communities but that substrate and hydrology accounted for changes instead.

In order to evaluate the discharge of these variables from Kentucky power plants, their loading potential into receiving waters was calculated using the flow rates of the outfall and receiving stream. The dilution factor was estimated by using one-third of the 7Q10 (low flow) to represent partial mixing and dividing it by the average annual flow rate of the outfall. The resulting value is an estimate of the average dilution that occurs when the outfall empties into the receiving stream and undergoes partial mixing. Where the flow of the receiving stream is 0, the dilution factor is 1.0, indicating that there is no dilution. For outfalls where the outfall and the receiving stream are similar in magnitude, the flow of the outfall may contribute significantly to the total flow of the receiving stream. Therefore, for outfalls where the dilution factor that was calculated was less than 10, the flow of the outfall was added into the flow of the receiving stream. For example, for Kentucky Utilities' E.W. Brown Generating Station, the calculated dilution factor for the harmonic mean flow of the receiving stream would be 3. The ratio between the flow rate of the stream and the outfall is 3:1 and a dilution factor of 4 indicating the outfall flow would make up 25 percent of the total flow, and the concentration after partial mixing into the receiving stream would be ¼ that of the outfall. All dilution factors were rounded to a whole number.

To estimate the concentration of contaminants in the receiving waterbody, the concentration in the outfall was divided by the dilution factor (see Appendix C, Table 2). Where concentrations were below the laboratory detection limit, then one-half of the detection limit was applied to each value. By calculating the concentrations of these parameters entering receiving waterbodies using 200 as a default hardness value, KDOW Water Quality Standards (WQSs) (401KAR 5:031, Table 2) were periodically exceeded by various facilities for chromium, copper, lead, manganese, nickel, selenium, zinc, and iron (Table 3). Six of the 12 plants had calculated exceedences of WQSs for the Warm Water Aquatic Habitat (WAH) use category.

Table 3. Susceptibility (as percent) of all power plants to exceed calculated WQSs for WAH (1997-2000).

Parameter	**Arsenic**	**Cadmium**	**Chromium**	**Copper**	**Lead**	**Manganese**	**Mercury**	**Nickel**	**Selenium**	**Zinc**	**PCBs**	**Iron**
Number of Samples	96	64	141	143	100	132	64	106	95	214	48	191
Number of WQS Exceedences	0	0	25	35	6	14	0	25	11	118	*	89
% Violations	0.0	0.0	17.7	24.5	6.0	10.6	0.0	23.6	11.6	55.1	*	46.6

*32 PCB observations were non-detect, outfall flow data for remaining 16 samples was not available to calculate loading.

Table 4. Percent of samples with calculated WQSs exceedences for parameters without set concentration limits (1997-2001).

Facility	**Arsenic**	**Cadmium**	**Chromium**	**Copper**	**Lead**	**Manganese**	**Mercury**	**Nickel**	**Selenium**	**Zinc**	**PCBs**	**Iron**
CINCINNATI G & E E BEND STEAM	0	0	0	15.8	0	0	0	15.8	0	15.8	0	0
EAST KY POWER COOP COOPER STAT				100								0
EAST KY POWER COOP DALE STEAM				100								0
EAST KY POWER COOP SPURLOCK ST				0		0						0
KY POWER CO BIG SANDY PLANT	0		98.4	75	0			100	100	74.8		40
HENDERSON POWER & LIGHT STA #1				0								0
LOUISVILLE G & E TRIMBLE STA		**No**		**Flow**		**Data**						
TVA KY HYDRO PLANT		**No**		**Flow**		**Data**						
TVA PARADISE FOSSIL PLANT	0			39.5	18.7	55.5		50	43.8	62.5		3.8
TVA SHAWNEE FOSSIL PLANT	0			0	0			0	0	0		0
WESTERN KY ENERGY CORP REID GR	0		100	100	30	80		100	0	100		50
WESTERN KY ENERGY CORP WILSON				0								0

Heavy metal contamination or loading into receiving waterbodies may cause physiological and neurological burdens upon aquatic organisms as well as the bioaccumulation of these metals in fish tissue. Predatory birds and mammals also accumulate these toxins through consumption of fish. Pertinent to this study, chromium, copper, lead, and nickel all have moderate to high environmental hazard and ecological risk rankings due to known toxicity and persistence (see Hertwich et al., 2001, Davis et al., 1994). On the other hand, manganese, selenium, and zinc have low to moderate environmental hazard and ecological risk rankings. However, it is uncertain whether any of these metals are bio-available which depends on complex chemical interactions between the metals and other parameters (e.g., hardness, pH, and temperature). It is assumed that through Whole Effluent Toxicity (WET) testing, potential effects can be monitored and evaluated.

Although reported DMR data showed that no power plant exceeded calculated WQS for mercury (high toxicity and persistence), reported year 2000 Toxic Release Inventory (TRI) values for mercury (EPA 2001, unverified data) showed that 555.25 lbs. of mercury were discharged by power plants into seven streams in Kentucky. Two TVA plants (Shawnee and Paradise) accounted for 86% of Kentucky power plants' total stream mercury discharge (Ohio River and Green River, respectively). Currently, Kentucky has issued a statewide fish consumption advisory for mercury because of its human health risks. The quantifiable risks associated with this source of water-discharged mercury are not well understood. Mercury contamination will be discussed below in the air quality section.

Existing power plants are currently undergoing ammonia-injection retrofits for use in the Selective Catalytic Reduction (SCR) process. Potential nitrogen loading is expected to occur from ammonia as part of the process. Many of the existing plants are installing these units to lower NO_x emissions. In SCR technology, ammonia is injected into the SCR system and may result in ammonia emissions and may also be partially bound in the ash as a result of the coal-fired power plants installing SCR units. Anticipated problems associated with this may be an exceptional degree of loading from ammonia and other nitrogen series nutrients into receiving waterbodies. Whether air deposited, or leached from treatment ponds, excessive loading could lead to general eutrophication (e.g., nuisance algal blooms, taste and odor problems, fish kills, and overall reduction in aquatic life quality).

Toxicity Data

Bioassay/Toxicity Testing is used to monitor the effect that effluents have on test organisms. Nineteen power plants require toxicity testing through their KPDES monitoring. Test organisms include the microcrustacean *Ceriodaphnia dubia* and the fathead minnow *Pimephales promelas.* Depending on the size of the receiving streams(s), either acute (two day test) and/or chronic (seven day test) testing may be required. Toxicity is expressed as Toxicity Units (TU) which is a unit measure for effluent toxicity. The TU of a test increases as the toxicity of the effluent increases. For example, a TU of 4.0 is twice as toxic as a value of 2.0. Acute tests use the LC_{50} (lethal concentration where effluent concentration causes 50 percent of the test organisms to die) for calculating TUs. For chronic tests, the IC_{25} (inhibition concentration where effluent concentration causes a 25 percent reduction in organisms reproduction or growth) is used for TU calculation. A covariant parameter such as water hardness is also reported with the results of each test. Effluent hardness values greater than 200 typically indicate that metals are not likely to be the source of toxicity. Historical toxicity evaluations dating back to 1993 (for some permittees) were retrieved from the KDOW ToxTrac database and are summarized in Table 5. The frequency and magnitude of failure to pass such bioassay tests show that the majority of power plants seem to be operating within permit limits most of the time. This is also noted above in corresponding DMRs (Table 2). Despite a low overall failure rate by the industry in general, excessive toxicity was reported for four plants (Table 5). Gross toxic pollution may be inferred from these data with the LC_{50} found at only 6 to 30 percent effluent concentration. For example, a TU of 5.0 (i.e., East Kentucky Power, Cooper Station) would indicate that effluent diluted to 20% caused half of the test organisms to die. A TU of 16.0 (i.e., Louisville G&E, Mill Creek Station) would be considered extremely toxic since only 6% effluent concentration would cause half of the organisms to die.

Table 5. Bioassay/Toxicity Test Histories for Power Plant Facilities (1997-2001).

Facility	Toxicity Tests Submitted	Total Tests Failed	TU Limit	Maximum TU
CINCINNATI G & E E BEND STEAM	6		1.0	
EAST KY POWER COOP COOPER STAT	9	2	1.0	5.5
EAST KY POWER COOP DALE STEAM	15		1.0	
EAST KY POWER COOP SPURLOCK ST	8		1.0	
HENDERSON POWER & LIGHT STA #1	17		1.0	
KY POWER CO BIG SANDY PLANT	33	13	1.0	9.1
KY UTIL E W BROWN GEN STA	5		1.0	
KY UTIL GHENT GENERATING	5		1.0	
KY UTIL GREEN RV GEN STA	5		1.0	
KY UTIL PINEVILLE GEN STA	4		1.0	
KY UTIL TYRONE GEN STA	5		1.0	
LOUISVILLE G & E CANE RUN STA	34		1.0	
LOUISVILLE G & E MILL CRK STA	34	3	1.0	16.0
LOUISVILLE G & E TRIMBLE STA	17		1.0	
OWENSBORO MUN UTIL SMITH STAT	17		1.0	
TVA PARADISE FOSSIL PLANT	43	2	1.0	3.4
TVA SHAWNEE FOSSIL PLANT	16		1.0	
WESTERN KY ENERGY CORP COLEMAN	19		1.0	
WESTERN KY ENERGY CORP REID GR	19		1.0	
WESTERN KY ENERGY CORP WILSON	18		1.0	

Thermal Discharge

Typically, the cooling process associated with gas, oil, and coal-fired facilities requires the discharge of thermally elevated water into receiving streams. While monitored by KPDES permitting, these limits may not reflect potential ecological impacts. The indirect effects of temperature may be biological or chemical in nature. This parameter has profound effects on primary productivity (i.e., the bottom of the food web), in both the quality and biomass produced (Hart and Fuller 1974). Elevated temperatures may increase the quantity of blue-green algae, a group known to produce compounds that are toxic to fish and livestock, and produce taste and odor problems in public drinking water. Other temperature impacts to stream ecosystems may entail the modification of crucial life history phenologies in fish and shellfish resulting in unsuccessful reproduction, premature death, and alteration of community structure. Freshwater mussels and fish have distinct temperature requirements to initiate important life history events (e.g., spawning). Since mussels are directly dependent upon their respective fish host (i.e., parasitic glochidial or larval stage), a disruption of breeding and distributional optima in fishes will also affect the reproductive success of mussels.

Avoidance of unseasonably warm waters (i.e., induced by thermal discharges) by naturally occurring organisms will ultimately change or alter community structure (e.g., different fish and macroinvertebrate communities). The life history of aquatic insects, probably the most numerous inhabitants of surface waters in Kentucky, is naturally affected by the annual thermal regime. Increased temperatures may disrupt the seasonal emergence pattern of aquatic insects. Unseasonably high temperatures in winter may cause emergence up to 5 months early. This could affect natural communities because insects emerging too early in the season may be killed or inactivated by low ambient air temperatures (Weiderholm 1984). Overall, these effects may equate to a change in the designated aquatic-life use of the receiving waterbody. However, because many power plants discharge cooling water into large, modified rivers, their effects are often ameliorated. While impacts may be severe within mixing zones, documentation on downstream effects of power plant cooling systems (Epsey et al. 1978) showed negligible impacts to plankton, ichthyoplankton, fish, and macroinvertebrates. Moreover, the permanent loss of lotic, or flowing habitats due to impoundment (i.e., lock and dams) on some of these rivers may likely offset the biotic potential of the waterbody to harbor naturally occurring communities. KDOW currently does not assess ecological communities in these non-wadeable rivers but aquatic life use-support designations are based on water chemistry data.

Water Withdrawal

Water withdrawal (discussed in Appendix F) is an important factor since all gas, oil, or coal fired power plants use considerable amounts of water in the cooling process and often as a means to transport ash and/or slurry to retention basins. Although some power plants are currently exempt from reporting water withdrawal amounts, KDOW has data on several of them. Potential impacts associated with this process may include (1) entrainment of fish and their larvae, or direct mortality from being caught on intake screens; and (2) reduction in instream habitat at times of low-flow, especially during peak production times (summer). By reducing stream volume, habitats such as root mats, shoals, or woody snags may be exposed thereby eliminating substrates available for invertebrate colonization or fish cover.

Groundwater

Leachate from unlined ash and slurry ponds eventually seeps into terrestrial and aquatic food webs through groundwater. Leachate susceptibility depends on factors such as soil type/permeability (sand and loam at highest risk), and mean annual rainfall (>30 inches at highest risk). For instance, floodplain terraces composed of alluvial soils may be highly susceptible to groundwater contamination. In addition, karst areas are also highly susceptible. KDOW floodplain permits showed that there are 5 existing facilities with fly ash landfills or ponds situated on river floodplains.

An analysis of groundwater data collected from Louisville Gas & Electric's Mill Creek Power Plant (see Appendix D) was conducted to evaluate potential ecological impacts. For human health risks, arsenic and barium were found to be potential contaminants. Barium has a relatively low tendency to bioaccumulate in aquatic organisms, but it has neurological and developmental effects. Overall, it has a low ecological receptor risk. Arsenic has a higher ecological receptor risk associated with it. As stated in Appendix D, this study of groundwater impacts from ash landfills does not take into account the SCR process that uses ammonia. Ammonia bound up in the ash could leach into groundwater and be discharged into surface waters. See the previous section on chemical data that discusses potential impacts from ammonia loading for additional information.

Siting Issues

Power plants are usually located near moderate to large waterbodies. Often, riparian areas, wetlands, floodplains, and stream banks can be impacted when they are within close proximity to these facilities. Floodplains and wetlands, karst areas, or other important wildlife areas need to be carefully considered when constructing new facilities. A review of KDOW floodplain permits, KDWM landfill permits, and 401 Water Quality Certifications indicated various construction operations on these areas. Barge loading and fleeting facilities, ash landfills, ash piping systems, ash storage impoundments, coal stockpiles, leveling and grading, pipelines, and water intake structures may encroach upon and impact floodplains, riparian forests and river banks, and wildlife habitat. One existing ash landfill was constructed over developed karst geology. In this case, karst areas may enhance the seepage or infiltration of fly ash contaminated waters into groundwaters and nearby streams. National Wetland Inventory maps show that several existing power plants are situated in close proximity to jurisdictional wetlands.

An additional power plant pollutant is noise. Rotating turbomachinery and other noise associated with the facilities may cause avoidance by and harassment of wildlife species (waterfowl, raptors, songbirds, and mammals). The proximity of facilities to important nesting or feeding grounds of waterfowl or other sensitive species need to be evaluated.

Overall, siting issues are important because aquatic and terrestrial wildlife can be affected by (1) habitat loss/modification due to facility construction, (2) harassment from noise of machinery, and (3) reduction of air/water quality in the vicinity of these sensitive areas.

Air Quality

Ecological considerations for ambient air or airshed pollutants are far reaching and may depend on many factors. Acid depositional patterns for soil and water, phytotoxicity, mercury deposition in surface waters, proximity to other air point sources, and topography are some important factors to examine.

Acid Deposition

It has been well documented that atmospheric deposition of acid-forming compounds have altered terrestrial and aquatic communities in various regions around the globe (Dillon et al., 1984). Acid deposition affects the environment in several different ways. In aquatic systems, acid deposition can affect these ecosystems by lowering their pH. However, not all aquatic ecosystems are affected equally. Streams, ponds or lakes that exist within limestone areas (e.g., Bluegrass and Pennyroyal regions) are naturally buffered from the effects of acid deposition. Aquatic systems with predominant sandstone lithologies (e.g., western and eastern coalfields) are normally very sensitive to acid deposition because they lack basic compounds that buffer acidification. For example, two important bodies of water in Kentucky, Bad Branch (a Wild and Scenic River in Letcher County) and Martins Fork (a Wild and Scenic River in Harlan County) appear to be experiencing acid stress with pH values near 5.0. Neither of these streams have experienced coal mining (i.e., acid mine drainage) and it is hypothesized that atmospheric acid deposition along with low natural buffering capacity is the cause. One of the most obvious effects of aquatic acidification is the decline in fish and macroinvertebrate density and richness. Acidified waterbodies may also contain high concentrations of toxic heavy metals like aluminum, mercury, and cadmium. Heavy metals are naturally present in the surrounding soil and bedrock. Normally, these chemicals are found locked in clay particles and minerals, but the acidification of terrestrial soils and bedrock can cause these metals to become soluble. Once rendered soluble, infiltrating water leaches these metals into aquatic systems where they accumulate to toxic levels.

In terrestrial plant communities, the impact of acid deposition is dependent on the type of soil in which plants grow. Similar to surface water acidification, many soils have a natural buffering capacity and are able to neutralize acid inputs. In general, soils that have a lot of lime (e.g., Bluegrass and Pennyroyal regions) are better at neutralizing acids than the sandstones and shales of eastern Kentucky. Eastern and Western Coalfields. Upland terrestrial habitats within Mammoth Cave National Park, an International Biosphere Reserve, could be at risk from acidic deposition from existing and proposed coal-fired plants (because of the extensive sandstone caprock within the Park). In less buffered soils, vegetation is affected by acid deposition because: (1) higher acidity results in the leaching of important plant nutrients, including calcium, potassium, and magnesium; (2) low availability of these nutrients may cause a decline in plant growth rates; (3) aluminum (a toxic heavy metal) becomes more mobile in acidified soils and can damage roots and interfere with plant uptake of other nutrients; (4) reductions in soil pH can cause germination of seeds and the growth of young seedlings to be inhibited; (5) important soil organisms cannot survive in soils below a pH of about 6.0, and the death of these organisms can inhibit decomposition and nutrient cycling; and (6) acid precipitation can cause direct damage to the foliage on plants.

Phytotoxicity

Air emissions, particularly from coal-fired facilities, can cause the decline or death of naturally occurring plant communities but is dependent upon acute and chronic exposure concentrations of the various air pollutants. Of concern would be those forest communities growing along streams, rivers, and lakes, as well as more upland forests. Table 6 lists common species that would be typical of areas adjacent to power plants in Kentucky and their tolerance to SO_2 emissions (from USFWS, 1978). There is considerable variability in the sensitivities of riparian species. For example, large river riparian species in Kentucky such as boxelder maple, sycamore, silver maple, and willow all appear to be resistant or intermediate to SO_2 exposure, but sensitive species also occur. Upland species may be more susceptible where topographic relief is high. In hilly topography (e.g., eastern and northern Kentucky areas), effects of maximum daily concentrations of SO_2 and NO_x on forest communities may be enhanced. Here, sensitive commercial species such as Tulip Poplar may be affected. In addition, upland pine communities may be adversely affected directly or indirectly. Indirectly, physiological stress from air pollutants may enhance susceptibility of invasion from diseases and pests such as the southern pine beetle, which has decimated pine stands in much of eastern Kentucky.

Table 6. SO_2 Sensitive (S), Intermediate (I), and Resistant (R) Tree Species Common to Habitats Adjacent to Power Plants in Kentucky.

Species	**Habitat**	**Sensitivity**
Betula alleghanensis--Yellow Birch	Upland	S
Fraxinus pennsylavanica--Green Ash	Riparian	S
Pinus virginiana--Virginia Pine	Upland	S
Liriodendron tulipifera--Tulip Poplar	Upland	S
Acer negundo--Boxelder Maple	Riparian	I
Tilia americana--Basswood	Upland	I
Populus deltoides--Cottonwood	Riparian	I
Acer rubrum--Red Maple	Riparian/Upland	I
Quercus alba--White Oak	Upland	I
Nyssa sylvatica--Black Gum	Upland	R
Robinia pseudoacacia--Black Locust	Upland	R
Acer saccharum--Sugar Maple	Upland	R
Acer saccharinum--Silver Maple	Riparian	R
Quercus rubrum--Red Oak	Upland	R
Platanus occidentalis--Sycamore	Riparian	R
Salix spp.--Willow	Riparian	R

Mercury Deposition

Currently, Kentucky has a statewide mercury advisory in effect that recommends limits to the consumption of fish, particularly for children and women of childbearing age. See Appendix H on the health risks associated with mercury contamination. Mercury, while naturally present in small amounts in soils and bedrock, is thought to enter watersheds through atmospheric deposition. It has been widely accepted that excessive mercury loading into waterbodies across the nation is largely due to air deposition associated with coal-fired power plants (USEPA, 1997). Toxic Release Inventory values reported from Kentucky power plants (EPA, 2001, unverified data) in 2000, indicated that over 3,500 lbs. of mercury were released from air-stacks alone. This amounts to over half (55%) of the total mercury released from Kentucky power plants. Although an important human health risk, there are ecological effects from mercury as well. Animals higher up in the food web (e.g., predatory fish, fish eating birds) bioaccumulate mercury. While there is limited acute toxicity from air-deposited mercury has been elucidated, it is the chronic, persistent nature of mercury that appears to affect aquatic and terrestrial animals. In organisms, mercury affects important physiological and neurological functions.

Secondary Impacts

Non-direct impacts associated with power plants include the production, processing, and transportation of fuel material to the plant facilities. Permanent loss of land/or water and potential habitats may occur from utility right-of-ways, coal mining activities (contour mining, mountaintop removal, hollowfilling, slurry impoundments), river dredging for barge traffic, etc. U.S. Office of Surface Mining inventories indicate that approximately 330 miles of Kentucky streams have been permanently filled and buried with material associated with contour and mountaintop mining. In addition, KDOW estimates that approximately 700 miles of rivers are affected by surface mining. Oil and gas exploration, drilling, and piping also contributes to water pollution through increased sedimentation and potential brine-water discharge. While utility right-of-ways may create habitat by opening up travel corridors in the landscape mosaic, the effects of habitat fragmentation may also be substantial for certain species, particularly ones that require large contiguous tracts of forestland.

PROPOSED FACILITIES

The locations of proposed power plants have been loaded into an ARCVIEW project with corresponding topographic maps and National Wetland Inventory Maps. Topography, streams, and riparian habitats have been reviewed to determine potential impacts thought to be associated with these power plants. In addition, those streams listed as impaired (303(d) list or other), Exceptional Waters, Outstanding Resource Waters, Reference Reach waters, or Coldwater Aquatic Habitats were evaluated for proximity to proposed facilities.

Of the 22 proposed plants, six will be covered by existing permits, and two others have submitted applications for permits. Other proposed plants are still in the early stages of the planning and permitting process and have not yet submitted a KPDES permit application. Hence, information on the receiving streams for the proposed facilities was not complete at the time of this assessment. For those plants that did provide KDEP with more specific locations, it appears that none of them will be discharging wastewater into streams currently listed as either 303(d), Exceptional Waters, Outstanding Resource Waters, Reference Reach, or Coldwater Aquatic Habitat. However, a more detailed anti-degradation review should be required prior to permit approval. In addition, there are a number of streams adjacent to two of the proposed plants (Knott and Martin Co.) that are currently impaired (KDOW data) and a more thorough review of waste load allocations in these streams will be necessary during the application process. Also, two Reference Reach streams (Clemons Fork and Coles Fork) are within close proximity to the Kentucky Mountain Power facility (Knott Co.) and there should be concern for air emission impacts to these watersheds.

While several proposed plants are located within close proximity to jurisdictional wetlands, it is not anticipated that wetland acreage will be lost. However, wetland encroachment and destruction of riparian forests for facilities construction (e.g., barge loadout and fleeting, water intake structures, sediment control structures, etc.) may have impacts on plant and animal communities.

SUMMARY AND CONCLUSIONS

Although there was a limited time frame to complete this assessment, several important ecological observations were considered. The majority of the existing power plants appear to be operating within set permit limits for surface water discharges. However, frequent violations (>10%) occurred at several plants for various parameters. We must assume that this excess pollution may harm aquatic life in Kentucky waterbodies. Gross toxic pollution occurred at 22 percent of the plants as verified through toxicity testing with bioassay test organisms. Heavy metal loading (e.g., chromium, copper, lead, zinc, etc.) as assumed from calculated exceedences of WQSs must also be construed as being harmful to aquatic life. Thermal impacts have not been thoroughly studied with the existing power plants but the DMRs show that violations do occur. Although the environmental effects of water withdrawal cannot be analyzed with the data at hand at this time, there are serious implications to consider with regard to the protection of aquatic fauna and their habitats, especially from water consumers during low-flow periods (i.e., summer). The ecological effects of groundwater contamination also cannot be thoroughly assessed at this time for lack of data. It would be protective to assume that unlined landfills in floodplain areas (i.e., sand or silt-loam soils) could pose threats to aquatic and terrestrial biota. Siting issues are far reaching but a focus on factors, such as the proximity of power plants to important ecological areas (e.g., wetlands, waterfowl nesting areas, riparian forests, karst areas), must be thoroughly considered to avoid habitat destruction or harassment of wildlife from noise and reduction of near-plant air and water quality. KDEP does not have site-specific data on these assumed factors. Acid deposition (acid rain) from coal-fired plants can cause a serious impact in certain areas (i.e., sandstone regions) to both aquatic and terrestrial ecosystems. In addition, mercury deposition from air-stacks is considered to be most responsible for the current statewide fish consumption advisory in Kentucky. Finally, the secondary impacts from existing and proposed power generation include any burdens the electric industry places on land, air, and water through coal mining, oil/gas drilling, fuel transportation and refinement, power transmission line corridors, or river dredging for barges that deliver fuel and wastes. In order to be protective, we should assume that the increase in power generation in Kentucky will contribute similar impacts like existing plants but may also compound environmental problems that exist today.

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Appendix F

Power Plants Impact Study
Water Supply Issues

Prepared by:

Kentucky Department for Environmental Protection

Division of Water

KPDES Branch

December 17, 2001

POWER PLANTS IMPACT STUDY - WATER SUPPLY ISSUES

BACKGROUND

The topic of water supply and water withdrawal has been identified by the Department for Environmental Protection as a potential problem area with regard to the issue of expanding numbers of power plants within the state. This topic is germane because nearly all power generating facilities require water to operate and some use sizable quantities. A typical fossil-fueled steam electric plant withdraws water from a nearby water body (river, lake or ground water) and uses it for a variety of purposes. These uses include, but are not limited to, boiler feed water, cooling water, equipment cleaning, combustion ash transport and on-site sanitary facilities. Other types of power plants such as turbine-based "peaking" installations usually require smaller amounts of water.

Two other observations have some bearing on this topic. Although some generating plants may withdraw large quantities of water, not all of it is consumed or evaporated. Usually some of the intake is returned to the same water body from which the initial intake was made. While this practice reduces the water supply burden somewhat, the source waters must still carry sufficient amounts of water to serve other functions. These functions include drinking water intakes, agricultural uses, industrial intakes, aquatic life support and many others. Offsetting this concern is the realization that most water-intensive power plants are located on large bodies of water. These large water bodies typically have flow values high enough to supply power plant intakes without endangering other uses.

WATER WITHDRAWAL PERMITTING

To keep track and reconcile all of the previously mentioned water uses, the Commonwealth adopted a water withdrawal permitting program. This program is authorized under KRS 151.140 and administered by the Water Resources Branch of the Division of Water. All withdrawals of water are subject to this permitting program unless it falls under one of three exemptions. These exemptions are for withdrawals of less than 10,000 gal/day, withdrawals for steam electric generating plants regulated by the PSC (Public Service Commission) and agricultural uses. Withdrawals from ground water are not exempt and all ground water applications are routed through the Division of Water's Groundwater Branch. That branch maintains a comprehensive database on ground water sources including springs. Due to these exemptions, the water supply database has numerous "gaps" and cannot provide a comprehensive list of withdrawals from each body of water.

POTENTIAL WATER SUPPLY PROBLEMS

As a consequence of the aforementioned incomplete listing of water withdrawals, there is insufficient data to determine if the combined intakes of proposed and existing power plants will create water availability problems at many locations. However, using other sources of information a rough comparison of existing water intakes and stream flow rates was compiled (refer to table 1.)

Table 1.
WITHDRAWAL & SUPPLY ISSUES FOR EXISTING POWER PLANTS WATER

Plant	Water Source	Intake Flow, MGD	Stream Flow, MGD	Intake as % of Stream Flow
CG&E, East Bend	Ohio R.	19.5	37046	0.05
EKP, Cooper	Cumberland R.	383	N/A (Lake)	N/A
, Dale	Kentucky R.	109	593	18.4 (Regulated Pool)
,Spurlock	Ohio R.	7.2	32690	0.02
, Smith	Kentucky R.	0.3	565	0.05
Henderson City, Henderson 1	Ohio R.	20.4	50388	0.04
KP, Big Sandy	Big Sandy R.	19.4	1057	1.8
KU, Brown	Herrington Lake	18.4	N/A	N/A
,Ghent	Ohio R.	71.1	35660	0.20
,Green R.	Green R.	283	2509	11.3
,Pineville	Cumberland R.	0.037	125	0.03
, Tyrone	Kentucky R.	184.1	667	27.6
LG&E, Cane Run	Ohio R.	373	37080	1.00
, Mill Creek	Ohio R.	270	37080	0.73
,Ohio Falls	Ohio R.	5.04	37080	0.01
, Paddy's Run	Ohio R.	1.49	37080	.004
,Trimble Co.	Ohio R.	9.2	37080	0.02
O'boro, Smith	Ohio R.	216	41990	0.51
TVA, Paradise	Green R.	359	2450	14.6
,Shawnee	Ohio R.	1177	113050	1.04
WKE, Coleman	Ohio R.	280	41667	0.67
,Reid/Green	Green R.	81	3295	2.46
, Wilson	Green R.	6.08	2515	0.24

The values in the final column are analogous to those used within the Division of Water's Water Resource Branch for deciding when a requested withdrawal constitutes to large a fraction of the water body's flow. Since that Branch uses a 10% figure as a rough guide, that leaves three plants that may cause water supply problems. These plants are KU-Green River, KU-Tyrone and TVA-Paradise facilities.

Although quantitative conclusions about the cumulative effects of these withdrawals are not possible at this time, a few observations can be made. First, should the state return to drought conditions such as the drought of 1988/89, there could be significant impacts on water availability. Obviously this will magnify any water supply shortages that may be caused by the new power plant intakes.

If any of the proposed plants plan to wash coal on-site, that process will also require a supply of fresh water. For example, the Cash Creek plant may use up to 1.3 MGD for washing the locally mined coal. (This rate assumes approx. 6,000 to 7,000 ton/day of coal and about 200 gal. Make-up water per ton of coal washed.) Fortunately, this additional intake only constitutes 0.04% of the Green River's harmonic mean flow.

Another potential problem is that the peaking plants will have their greatest water needs during the summer months, a period that coincides with low stream flows, high evaporation/transpiration rates and higher irrigation needs. The Division of Water will need to track stream flow rates during these worst case conditions to see if water withdrawal restrictions will need to be imposed.

To relieve these concerns, water users on smaller streams may need to look into providing on or off-site water storage. Large ponds or reservoirs could accumulate water during the rainy season and provide a short term water supply that would not impact stream flows.

A related topic is the potential impacts on existing WTP (water treatment plant) intakes from the siting of the new generating plants. Table 2. Presents a list of proposed plants matched with projected impacts on WTP's or their Source Water Assessment & Protection Plans (SWAPP's).

SWAPP's are used by various planning groups to identify potential contamination threats within the areas upstream of public water supplies. Each SWAPP contains an inventory of these possible contamination sources broken down into three "zones". Zone 1 refers to an area reaching from ¼ mile below the water supply intake to a distance of 5 miles upstream. The selection of 5 miles was intended to be compatible with the Division of Water's "Five Mile Policy" (a brief explanation of which is below). Zone 2 would inventory moderate and high hazards of contamination in the water supply starting at 5 miles and extending to 10 miles upstream (this corresponds to the distance most streams would cover in about 1 to 5 hours). Zone 3 then provides for a listing of water supply threats in the area 10 to 25 miles upstream of the intake or within 2 ½ to 12 ½ hours of stream travel. Related to this concept of protecting water supplies from contamination is the Division of Water's "Five Mile Policy" which prohibits new sources of wastewater within 5 miles upstream of a water treatment plant intake. The policy also prohibits new drinking water intakes within 5 miles downstream of known discharges of wastewater.

Table 2
PROPOSED POWER PLANTS – IMPACTS ON WTP's

County	Name	Fuel Type	WTP Proximity
Breckenridge	Dayton Power / Light	Nat. Gas/Oil Peaking	Not within 5 miles or any SWAPP
Campbell	Trigen-Cinergy	Nat. Gas Peaking	Within 5 miles of Newport WTP and NKWSD WTP and in Zone 1 SWAPP for Newport WTP
Clark	EKP – J. K. Smith	Nat. Gas/Oil Peaking	Within Zone 3 SWAPP for Winchester WTP
Clark	Global Energy-Ky. Pioneer Energy	Gasified Coal/Garbage Baseload	(same as above)
Estill	Calla Energy	Waste Coal Baseload	Within Zone 3 of Richmond WTP
Henderson	Cash Creek	Unknown	Not within 5 miles or any SWAPP
Henderson	Columbia Electric-Grane Creek	Nat. Gas Peaking	(same as above)
Jefferson	LG&E Paddy's Run	Nat. Gas Peaking	(same as above)
Kenton	Cinergy Energy Erlanger	Nat. Gas Peaking	(same as above)
Knott	Enviropower-Ky Mountain Power	Waste Coal Baseload	Within Zone 1 of Jackson WTP
Lawrence	Dynegy-Riverside	Nat. Gas Peaking	Not within 5 miles or any SWAPP
Marshall	Air Products & Chemicals	Nat. Gas Cogen.	(same as above)
Marshall	Duke Energy	Nat. Gas Peaking	(same as above)
Marshall	Enron Calvert City Power	Nat. Gas Peaking	(same as above)
Marshall	Westlake Energy	Nat. Gas Cogen.	(same as above)
Martin	Enviropower-Ky Eastern Power	Coal Baseload	Within Zone 3 of Martin Co. WD
Martin	Enviropower-Ky Western Power	Unknown	Not within 5 miles or any SWAPP
Mason	EKP - Spurlock	Coal Baseload	(same as above)
Metcalfe	Duke Energy	Nat. Gas/Oil Peaking	(same as above)
Muhlenberg	Thoroughbred Generating	Coal Baseload	Within Zone 1 of Central City WTP
Oldham	Dynegy Bluegrass	Nat. Gas Peaking	Not within 5 miles or any SWAPP

Trimble	LG&E Trimble Sta.	Nat. Gas Peaking	(same as above)

As discussed earlier, the lower SWAPP Zone designations refer to closer and therefore more immediate threats from discharges or spills. Accordingly, the following proposed plants may deserve closer scrutiny during the environmental permitting process. The Trigen-Cinergy plant planned for Campbell County is within the Zone 1 SWAPP's of two WTP's and within 5 miles upstream of one of them. Consequently, the new power plant will have to apply for a variance from the Five Mile Policy by demonstrating that their discharges with not pose any problems to the downstream intakes. And both WTP's' will have to identify any potential threats of contamination from the Trigen facility and formulate plans to counter these threats. This planning process may then feed back into the permitting process for the power plant and require, for example, the use of more fool proof or reliable spill containment measures. In like manner the Enviropower-Ky. Mountain Power and Thoroughbred Generating plants are within Zone 1 SWAPP's of the Jackson and Central City WTP's, respectively. Like the Trigen facility, this could lead to extra planning by the WTP's and extra discharge permit requirements on the generating plants.

One other water supply issue is the concept of inter-basin transfers. These transfers involve withdrawing water from one major basin and discharging it into a different major basin. Inter-basin transfer water withdrawal permit applications are handled differently and may trigger the need for a public hearing. The hearing would solicit comments on the merits and potential damages of allowing the inter-basin transfer. Fortunately, inter-basin transfers are seldom needed.

RECOMMENDATIONS

Although the necessary data are not available for a cumulative assessment of the water supply impacts of existing and proposed power plants, a few recommendations are possible.

The Department for Environmental Protection is currently engaged in a comprehensive revamping of its permit programs and associated databases. One of the goals is an increased amount of background information that would be readily available during any permit review process. The Department will also be moving toward a Geographical Information System (GIS) with multiple sources of data appearing on a single map. This improvement in information utility may allow future water withdrawal permit decisions to better account for multiple, existing subtractions from each water body. The Water Resources Branch could also identify "problem" reaches of streams where known water withdrawals account for a significant portion of the low flow quantities. These stream reaches could then be flagged as unsuitable for siting of future water-intensive activities (such as steam electric generating facilities).

To implement these water availability concerns for sites identified by the above process, water withdrawal permits can contain various conditions. These conditions include, but are not limited to, metering requirements, maximum rate of withdrawal, low-flow protection criteria, altering intakes to minimize impacts on downstream users and maintaining minimum flow values to preserve aquatic habitat.

Appendix G

Derivation of Human Health Screening Values

Prepared by:

Kentucky Department for Environmental Protection
Division of Environmental Services
Risk Assessment Branch

December 17, 2001

Introduction

Risk assessment is a formalized process for evaluating the potential human health and ecological impacts of environmental data. Risk assessment has increasingly been used in environmental decision-making since the publication of the National Research Council – National Academy of Sciences (1983) Red Book. That document outlined the process of risk assessment. U.S. EPA has produced several guidance documents to assist in assessing risks (U.S. EPA, 1989; 1991). Risk Assessment is a tool for evaluating human and ecological exposure to chemicals and their potential effects based on the toxicological research.

Human health risk assessment is a four-part process. The first step, Data Collection and Evaluation, assesses the available data and identifies chemicals of potential concern (COPCs). The next part, Exposure Assessment, identifies potential receptors and calculates their exposure. Toxicity Assessment, the third process, quantifies the toxicity of the COPCs for carcinogenic and noncarcinogenic effects. The final step of Risk Characterization is the calculation of the potential effects on the receptors identified in the Exposure Assessment, based on the toxicity of the chemicals identified in the Data Collection and Evaluation step.

Risk assessment procedures can be used in several stages of site assessment. Site scoping can use risk assessment to determine preferred detection limits and to screen initial data to focus on areas of concern. Data from Site Characterization can be screened against target risk-based concentrations (Preliminary Remediation Goals) to identify the chemicals that will be assessed in a full baseline risk assessment. Risk assessment is also used in setting remedial goals, and as an exit criterion for closure of remediation activities. Risk assessment is used as part of activities related to the Resource Conservation and Recovery Act (RCRA), Comprehensive Environmental Response, Compensation, and Liability Act (CERLCA), Clean Water Act, and Clean Air Act.

The Governor of Kentucky signed a Moratorium on June 19, 2001 on issuing permits for new power plants. The moratorium was implemented in order that the Natural Resources and Environmental Protection Cabinet (NREPC) and the Public Service Commission (PSC) could conduct studies of the impacts of increasing the electrical generating capacity in Kentucky. Because of the amount of data to be evaluated for the assessment of power plants in response to the Moratorium, it was decided that screening of the data with risk-based concentrations (as opposed to a baseline risk assessment) would allow the Natural Resources and Environmental Protection Cabinet (NREPC) to complete the assessment by December 7, 2001. The assumption that are used in estimating screening values are selected to be protective of sensitive subpopulations. Concentrations of chemicals in air and water were developed to assist NREPC personnel in evaluating the data. This appendix details the approach and assumptions used to derive human health risk-based concentrations.

Calculation of Risk-Based Values

The formulae for calculating the risk-based concentrations are mainly from U.S. EPA guidance including Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part A), commonly referred to as RAGS Part A (U.S. EPA, 1989) and RAGS part B (U.S. EPA, 1991). "Estimating Dermal and Inhalation Exposure to Volatile Chemicals in Domestic Water" (Schaum *et al.*, 1994) was used to represent the inhalation exposure to water based on the Whole House Dispersion Model.

KYDEP incorporated applicable exposure routes into each media exposure. Inhalation was the route that was used for air exposures. Tap water exposure included ingestion and inhalation for volatile chemicals. If the contaminant is not volatile, then ingestion was the only pathway that was considered. A compound was assumed to be volatile when the molecular weight was less than 200 mg/mol and the Henry's Law Constant (H) was greater than 10^{-5} atm-m^3/mol. Most of the chemicals that were detected in groundwater and surface water for the power plants were metals, which are nonvolatile. Mercury and PCBs were the only chemicals that included inhalation exposure in the estimation of a tap water screening value. Inhalation from tap water was estimated using the Schaum (1994) Whole House Exposure Model. The model describes the average indoor air concentration as a result of water use throughout the house. This model considers water use such as washing dishes, bathing, washing clothes, and cooking. The formula is:

$$C_a = \frac{WHF \times C_w \times f}{HV \times ER \times MC}$$

where:

Ca	= concentration in air, mg/m^3
Cw	= concentration in water, mg/L
WHF	= water flow rate in whole house, 890 L/day
HV	= house volume, 450 m^3

ER	= exchange rate, 10 air changes/day
MC	= mixing coefficient, 0.5 (unitless)
f	= fraction of contaminant that volatilizes, 0.5 (unitless)

The default values for these parameters were selected from the text of the Schaum (1994) chapter and are listed following the description. Recreational use of the surface water included incidental ingestion of water and dermal absorption while in the water.

Formulae

The formulae for calculation of the screening values are the result of taking the standard exposure equations used in risk assessments and solving for the concentration term. Toxicity values were used to represent the potential toxicity of each compound. Table 1 lists the toxicity values used for calculating screening values for power plants. These values are obtained from several sources. The source is listed next to each toxicity value. The sources, in order of preference are: U.S. EPA's Integrated Risk Information System (IRIS), U.S. EPA's Health Effects Assessment Summary Tables (HEAST), U.S. EPA's National Center for Environmental Assessment (NCEA), values that have been withdrawn from IRIS or HEAST, other EPA documents, and route extrapolation.

Table 1. Toxicity Values for Chemicals Associated with Power Plants.

	Oral Slope Factor	basis	Inhalation Slope Factor	basis	Oral Reference Dose	basis	Inhalation Reference Dose	basis
Arsenic	1.5E+00	IRIS	1.5E+01	IRIS	3.0E-04	IRIS		
Barium					7.0E-02	IRIS	1.4E-04	HEAST
Benzene	5.5E-02	IRIS	2.7E-02	IRIS	3.0E-03	route	1.7E-03	NCEA
Beryllium			8.4E+00	IRIS	2.0E-03	IRIS	5.7E-06	IRIS
Boron					9.0E-02	IRIS	5.7E-03	HEAST
Cadmium			6.3E+00	IRIS	5.0E-04	IRIS	5.7E-05	withdrawn
Chromium (total)			4.2E+01	IRIS				
Cobalt					6.0E-02	NCEA	2.9E-04	NCEA
Copper					3.7E-02	HEAST		
Formaldehyde			4.6E-02	IRIS	1.5E-01	IRIS	1.5E-01	route
Hydrogen chloride							5.7E-03	IRIS
Iron					3.0E-01	NCEA		
Lead (tetraethyl)					1.0E-07	IRIS	2.9E-04	Other EPA
Manganese					2.4E-02	IRIS	1.4E-05	IRIS
Mercury (elemental)					3.0E-04	IRIS	8.6E-05	IRIS
Nickel (soluble salts)					2.0E-02	IRIS		
Nickel refinery dust			8.4E-01	IRIS				
Polychlorinated biphenyls (PCBs)	2.0E+00	IRIS	2.0E+00	IRIS	2.0E-05	IRIS	2.0E-05	route
Benzo[a]pyrene	7.3E+00	IRIS	3.1E+00	NCEA				
Selenium					5.0E-03	IRIS		
Silver and compounds					5.0E-03	IRIS		
2,3,7,8-TCDD (dioxin)	1.5E+05	HEAST	1.5E+05	HEAST				
Toluene					2.0E-01	IRIS	1.1E-01	HEAST
Zinc					3.0E-01	IRIS		

The Risk-Based Screening Values are based on a target risk of 1 x 10^{-6} for carcinogens and a Hazard Index of 1.0 for noncarcinogens in each media. A carcinogenic risk of 1 x 10^{-6}, or one excess cancer in one million, is considered to be the target risk for Kentucky. It is based on the National Contingency Plan (U.S. EPA, 1990b) and is standard practice in risk assessment for *de minimis* risk, or essentially zero risk. The target Hazard Index of 1.0 indicates that the noncarcinogenic risk is below a toxicity threshold represented by the reference dose. The following formulae were used to calculate the risk-based screening values for each media.

Noncarcinogenic Effects

Ambient Air

$$\frac{(ED\_c \times BW\_c \times 365 \times THQ \times RfDi \times 1000)}{(IRA\_c \times EF\_r \times ED\_c)}$$

Tap Water (nonvolatiles have the second half of the denominator removed)

$$\frac{(BW\_c \times ED\_c \times 365 \times THQ \times 1000)}{\left(\frac{(IRW\_c < 3 \times 3) + (IRW\_c > 3 \times 3)}{ED\_c} \times EF\_r \times ED\_c \times 1/RfDo\right) + \left(\frac{(890 \times 0.5)}{(450 \times 10 \times 0.5)} \times IRA\_c \times EF\_r \times ED\_c \times 1/RfDi\right)}$$

Recreational

$$\frac{(BW\_c \times ED\_c \times 365 \times THQ \times 1000)}{(IRW\_rec \times ET\_swm \times EF\_swm \times ED\_c \times 1/RfDo) + (SA\_bath\_c \times Kp \times ET\_swm \times 0.001 \, {}^{L}\!/_{cm^3} \times EF\_swm \times ED\_c \times 1/RfDi)}$$

Carcinogenic Effects

Ambient Air

$$\frac{(AT \times 365 \times TR \times 1000)}{(InhF\_adj \times EF\_r \times SFi)}$$

Tap Water

$$\frac{(AT \times 365 \times TR \times 1000)}{(IFW\_adj \times EF\_r \times SFo) + \left(\frac{(890 \times 0.5)}{(450 \times 10 \times 0.5)} \times InhF\_adj \times EF\_r \times SFi\right)}$$

Recreational

$$\frac{(AT \times 365 \times TR \times 1000)}{(IRW\_rec \times ET\_swm \times EF\_swm \times \left(\frac{ED\_c}{BW\_c} + \frac{ED\_adol}{BW\_adol} + \frac{ED\_a}{ED\_a}\right) \times SFo) + (SFW\_adj \times K_p \times 0.001 \, L/cm^3 \times EF\_swm \times ET\_swm \times SFo)}$$

Four age adjusted factors were calculated for carcinogenic exposure calculations. The formulae for each factor is shown below.

Skin Contact Factor for Water

$$\left(\frac{SA\_bath\_c \times ED\_c}{BW\_c}\right) + \left(\frac{SA\_bath\_adol \times ED\_adol}{BW\_adol}\right) + \left(\frac{SA\_bath\_a \times ED\_a}{BW\_a}\right)$$

Inhalation Factor

$$\left(\frac{IRA\_c \times ED\_c}{BW\_c}\right) + \left(\frac{IRA\_a \times ED\_adol}{BW\_adol}\right) + \left(\frac{IRS\_a \times ED\_a}{BW\_a}\right)$$

Ingestion Factor for Water

$$\left(\frac{IRW\_c < 3 \times 3}{BW\_c}\right) + \left(\frac{IRW\_a,c > 3 \times 3}{BW\_c}\right) + \left(\frac{IRW\_a,c > 3 \times ED\_adol}{BW\_adol}\right) + \left(\frac{IRW\_a,c > 3 \times ED\_a}{BW\_a}\right)$$

Table 2 summarizes the exposure factors that were used to calculate the risk-based screening values. The values listed in Table 2 and the chemical-specific factors were obtained from U.S. EPA guidance documents for risk assessment listed in the references section.

Table 2. Exposure Factors

Parameter (units)	Value	Abbreviation
Target Cancer Risk	1×10^{-6}	TR
Target Hazard Quotient	1	THQ
Body weight, age 1-6 (kg)	14.5	BW_c
Body weight adolescent (kg)	43	BW_adol
Body weight, adult (kg)	70	BW_a
Averaging time (years)	70	AT
Surface area while swimming/bathing (cm^2/day) child	7200	SA_bath_c
adolescent	13500	SA_bath_adol
adult	18150	SA_bath_a
Inhalation rate (m^3/d)	20	IRA_a
	20	IRA_c
Drinking water ingestion (L/d)	2	IRW_a, c>3
	1	IRW_c<3
Incidental water ingestion rate (L/hr)	0.05	IRW_rec
Dermal permeability constant in water (cm/hr)	chemical specific	K_p
Exposure frequency (d/yr)	350	EF_r
	45	EF_swm
Exposure time (hr/day)	2.6	ET_swm
Exposure duration, age 1-6 (yr)	6	ED_c
Exposure duration, age 7-18 (yr)	12	ED_adol
Exposure duration, adult (yr)	12	ED_a
Total duration (yr)	30	ED_total
Age-adjusted factors (for carcinogens only)		
Skin contact factor for water ([cm^2*yr]/[kg-d])	9858.2	SFW_adj
Inhalation factor ([m^3*yr]/[kg-d])	17.28583	InhF_adj
Ingestion factor for water ([L*yr]/[kg-d])	1.521686	IFW_adj

Exceptions

Extrapolation. Some chemicals had only oral or inhalation toxicity values listed on the Region IX PRGs Table. In those cases, route extrapolation was necessary. Literature reviews were done to verify the potential for effects in other media of exposure.

Lead. U.S. EPA has implemented use of the IEUBK Model to estimate environmental levels that will result in a target blood lead level. KYDEP performed a review of lead issues (KYDEP, 1996) and determined that the most appropriate metric for lead risk assessment was the RfD_o and RfD_i derived based on the LOAEL in laboratory rats. For further discussion of lead see the Lead Issues document.

PCBs. PCBs also received special consideration. IRIS lists two Cancer Slope Factors for PCBs. The high risk slope factor (2.0 $(mg/kg\text{-}day)^{-1}$) was used based on the observation that as a mixture of PCBs weathers, the lower chlorinated biphenyls are more likely to degrade, leaving the higher chlorinated biphenyls in a higher proportion. Since the higher chlorinated biphenyl mixtures (Aroclor 1260) have higher toxicity, the high risk factor was used for the screening values. For noncarcinogenic effects, Aroclor 1254 is applied by KYDEP to represent the higher chlorinated mixtures (Aroclor 1260, 1254, and 1248).

Results

The screening values that were calculated using these methods are listed in Table 3. The basis for each value in the Screening Values table is denoted by “c” for a carcinogenic endpoint, and “nc” for a noncarcinogenic endpoint.

Table 3. Screening Values for Chemicals Associated with Power Plants (based on carcinogenic (c) or noncarcinogenic (nc) endpoints)

Chemical	Residential Tap Water (µg/L)	Recreational Water Use (µg/L)	Air ($\mu g/m^3$)
Arsenic	0.032 (c)	2.7 (c)	0.00028 (c)
Barium	0.55 (nc)	55000 (nc)	0.108 (nc)
Beryllium	0.0025 (c)	1600 (nc)	0.0005 (c)
Cadmium	0.0034 (c)	400 (nc)	0.00067 (c)
Chromium	0.0005 (c)	4000 (nc)	0.00011 (c)
Copper	370 (nc)	29000 (nc)	28.1 (nc)
Iron	3000 (nc)	24000 (nc)	---
Lead	0.001 (nc)	0.08 (nc)	0.22 (nc)
Manganese	0.054 (nc)	19000 (nc)	0.011 (nc)
Mercury	0.3 (nc)	79 (nc)	0.065 (nc)
Nickel	200 (nc)	16000 (nc)	0.005 (c)
Selenium	50 (nc)	4000 (nc)	3.8 (nc)
Silver	50 (nc)	4000 (nc)	3.8 (nc)
Zinc	3000 (nc)	24000 (nc)	227 (nc)
Benzene	0.41 (c)	3.9 (c)	0.16 (c)
Benzo(a)pyrene	0.003 (c)	0.004 (c)	0.0014 (c)
Chloroform	0.26 (c)	27 (c)	0.053 (c)
Formaldehyde	0.47 (c)	11000 (nc)	0.093 (c)
HCl	---	---	4.3 (nc)
Polychlorinated Biphenyls	0.0074 (c)	0.031 (c)	0.002 (c)
2,3,7,8-TCDD (dioxin)	9.9×10^{-8} (c)	1.6×10^{-7} (c)	2.8×10^{-8} (c)

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Appendix H

Summary of the Toxicity of Chemicals Related to Power Plants

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Introduction

This appendix summarizes the potential human health effects associated with the chemicals that were identified as chemicals of Potential Concern in Appendix G. The effects that were examined are based on oral, dermal, and inhalation exposure. The primary reference for each chemical is the Agency for Toxic Substances and Disease Registry's Toxicological Profile for each chemical. These studies compile the available literature on each chemical. Other references were consulted as needed.

The relevant tissues and organs and expected effects associated with exposure to these contaminants are contained in this appendix. Most of these studies are based on acute occupational exposures in humans and laboratory animal studies. Many of the studies were conducted at high concentrations. If a vast amount of data was available, emphasis was on documenting effects from intermediate and chronic duration of exposure rather than acute.

Ammonia

Long-term exposure to ammonia can cause irritation of the nose, eyes, throat and lungs of humans. It is also associated with pneumonitis, myocardial fibrosis, dyspnea of the lungs, and nasal lesions. Oral exposure is associated with swollen renal tubule epithelium, tubule degeneration, enlarged adrenal glands, reduced body weight and bone loss in animal studies (ATSDR, 1990a).

Arsenic

Arsenic has been known to be a poison to humans for many centuries. Large oral doses can produce death. Lower levels can produce irritation of the stomach and intestines (pain, nausea, vomiting and diarrhea), decreased production of red and white blood cells, fatigue, abnormal heart rhythm, damage to blood vessels, impaired nerve function, skin abnormalities (darkening, corns, warts, and skin cancer), and increased risk of liver, bladder, kidney and lung cancer. Arsenic is a known human carcinogen with one of the primary endpoints after inhalation at smelters and chemical plants being increased risk of lung cancer (ATSDR, 1998a).

Barium

Acute oral exposure to barium resulted in respiratory weakness and paralysis, high blood pressure, abnormal heart rhythm, gastric pain, vomiting, diarrhea, muscle weakness, hemoglobin in the urine, renal insufficiency, degeneration of the kidney, numbness, and tingling around the mouth and neck. Inhalation studies of barium are lacking in quality. There was a study of workers that indicated increased blood pressure and EKG abnormalities, but there wasn't a control population. Acute exposure to large quantities was reported to cause abdominal cramps, nausea, and vomiting, muscle weakness, and renal failure. Animal studies indicate hematological effects, impaired hepatic function, and increased blood pressure and cardiac irregularities at intermediate doses (ATSDR, 1992a).

Benzene

Oral exposure to benzene in high concentrations results in staggering gait, visual disturbances, euphoria, sleepiness, vomiting, shallow, rapid pulse, and eventually, death. Lower doses in animals resulted in decreased numbers of erythrocytes and leukocytes, impaired immune response, neurological effects in human and animals, and developmental and genotoxic impacts in rats. Carcinogenic effects observed in animal studies were squamous cell papillomas and carcinomas of the oral cavity, malignant lymphoma, alveolar and bronchiolar adenomas and carcinomas, ovarian tumors, cancer of the mammary gland, and leukemia. U.S. EPA has produced an oral slope factor for benzene based on leukemia.

High concentrations of benzene when inhaled have resulted in asphyxiation, respiratory arrest, central nervous system depression, cyanosis, hemolysis, congestion or hemorrhage of organs and death. Lower doses resulted in mucous membrane irritation, shortness of breath, hemorrhage and edema of the lungs, laryngitis, bronchitis, ventricular tachycardia, leukopenia, aplastic anemia, thrombocytopenia, bone marrow dysplasia, skin irritation, eye irritation, damage to the lymphatic and immune systems, peripheral neuropathy, headaches, memory loss, nausea, tremor, convulsions, irregular menstrual cycles, spontaneous abortions, chromosomal aberrations, and leukemia (ATSDR, 1997a).

Benzo(a)pyrene and other Polycyclic Aromatic Hydrocarbons (PAHs)

Many of the PAHs have similar toxicological endpoints. Benzo(a)pyrene is considered to be the most potent of the PAHs and also has been studied more often. Chronic exposure of workers to PAHs resulted in reduced lung function, abnormal x-ray, cough, bloody vomit, throat and chest irritation and decreased immunological function.

Respiratory tract tumors and neoplasms of the upper digestive system were observed in hamster studies. Epidemiological studies have indicated an increase in mortality due to lung cancer in workers exposed to coke oven emissions, roofing tar emissions, and cigarette smoke. Other carcinogenic compounds are part of these emissions (nitrosamines, coal tar pitch, and creosote) so the total carcinogenicity of the PAHs could not be determined. Oral exposure to benzo(a)pyrene and other PAHs were associated with aplastic anemia, increased liver, spleen, and kidney weight, gastric tumors, papillomas and squamous cell carcinoma (ATSDR, 1995b).

Beryllium

Beryllium exposure has been associated with acute and chronic respiratory disease and death in workers exposed to beryllium and its compounds. Inhalation exposure can result in acute pneumonitis, granulomatous lung lesions (berylliosis), irritation of the nasal and pharyngeal membranes, sore nose and throat, weight loss, decrease lung capacity, fatigue and weakness. Other effects include enlargement of the heart, and chronic beryllium disease, which has been determined to be an immune response. Exposure to beryllium has been associated with an increase in lung cancer (malignant neoplasm of the trachea and bronchus in occupational workers), but there are some confounding factors (smoking, improper calculation of expected incidence, and others) that were not controlled for in early studies, so human data is limited. Very little data is available on the effects of beryllium exposure via ingestion. Dermal exposure has been observed to cause dermatitis, spleen histological changes, edema, and allergic response (ATSDR, 1993).

Boron

Inhalation exposure to boron in dusts caused upper respiratory tract irritation, and eye irritation in workers. Oral exposure for humans to boron resulted in vascular congestion and hemorrhages of the lung, jaundice, fatty changes and congestion of the liver, vomiting, and diarrhea after acute exposure. Intermediate and chronic studies with rats and mice resulted in decreased body and spleen weight, reduced fetal weight, skeletal deformations, reproductive effects on the testes, and in some cases mortality (ATSDR, 1992b).

Cadmium

Intermediate and chronic animal exposure to cadmium via inhalation resulted in decreased body weight, increased immunological parameters (leukocytes, macrophages), increased lung dry weight, increased lung fibroblasts and collagen, increased heart, liver, spleen, brain, and kidney weight, emphysema, pneumonia, proteinuria, lung bronchioalveolar adenomas, adenocarcinomas and squamous cell carcinomas in humans and animals. Oral exposure resulted in decreased body weight, hepatic necrosis of central lobules, necrosis of renal proximal tubular epithelial cells and cloudy swelling, congested myocardium, separation of muscle fibers, anemia, proteinuria, decreased hematocrit and hemoglobin, decreased bone strength, emphysema, pancreatic atrophy, muscle atrophy, and peripheral neuropathy (ATSDR, 1999a).

Chloroform

Inhalation of chloroform by humans may result in depression of the central nervous system (somnolence, dizziness, and fatigue), liver damage, and kidney damage, pneumonia, and pneumonitis. Oral exposure to chloroform results in decreased body weight, decreased neutrophils, degeneration of renal tubules, increased liver and kidney weight, albuminuria. Animal studies indicate that chloroform is a carcinogen after oral exposure to rats. Tumors have been observed in the kidney and liver (ATSDR, 1997b). It is theorized that human exposure to trihalomethanes (bromoform, chloroform, and bromodichloromethane) may increase the risk of rectal, bladder, and colon cancer (ATSDR, 1997b).

Chromium

Effects that have been observed in humans are chronic tonsillitis, chronic pharyngitis, minor renal impacts, runny nose, ulceration of nasal septum, stomach pains, cramps, ulcers, and lung cancer. Inhalation of chromium by animals resulted in emphysema, increased white blood cell count, decreased body weight, inflammation of lung tissue, and adenomas and adenocarcinomas. Carcinogenic effects are suspected to be mainly due to the hexavalent form of chromium. Oral exposure resulted in decreased body weight, changes in liver enzyme activity, impaired immunological function, reproductive impacts in animals (ATSDR, 2001a).

Cobalt

Inhalation of cobalt has been associated with inflammation of the larynx, cardiomyopathy, decreased body weight, and emphysema. Oral exposure can cause vomiting, cardiomyopathy, increased lung, and heart weight, renal tubule necrosis, and testicular degeneration (ATSDR, 2001b).

Dioxin

Dioxin is considered to be a multisite, multisex, multispecies carcinogen and thought to be the most potent carcinogen. The primary cancerous endpoint for dioxin is soft tissue sarcoma resulting from TCDD-contaminated phenoxy herbicides. There is also some evidence of dioxin causing Non-Hodgkin's Lymphoma, lung cancer, and immune suppression that could weaken the body's ability to counteract precancerous lesions. The noncancerous endpoints with the most evidence are chloracne, increased gamma glutamyl transferase (a liver enzyme) production, increased liver size, diabetes and increased fasting glucose levels, altered reproductive hormone levels, temporary respiratory irritation, and tracheobronchitis. There are several endpoints that may be a result of dioxin exposure that need further research to determine if those effects are actually associated with dioxin exposure. Those effects include circulatory disease, general reproductive and developmental effects, spontaneous abortions, congenital malformations, decreased birth weight, immunological effects, and impaired thyroid function (U.S. EPA, 1994).

Formaldehyde

Inhalation exposure to formaldehyde is associated with effects on nasal epithelium and laryngeal tissue, respiratory and nasal irritation, mild tearing of the eye, conjunctival hyperemia, nasal congestion and discharge, hoarseness, and nasal tumors, squamous cell carcinomas in animals. Oral exposure to formaldehyde caused stomach ulcers, decreased body weight, gastritis, and renal impacts (ATSDR, 1999b).

Hydrogen Chloride

Inhalation exposure in animal studies indicated epithelial and squamous hyperplasia of the nasal mucosa, laryngeal and tracheal hyperplasia, lesions of the anterior portion of the nasal cavity, cheilitis, accumulation of macrophages in peripheral tissue, and eosinophilic globules in the epithelial lining of the nasal tissues (U.S. EPA, 1995).

Iron

Iron is an essential nutrient, but some effects have been observed at levels above beneficial doses. Chronic exposure via inhalation results in mottling of the lungs and benign pneumoconiosis. Some research is being done on the hypothesis that high iron stores (a genetic predisposition – hemochromatosis) may increase the risk of chronic disease including cancer and heart disease through oxidative mechanisms (ASNS, 1999). Exposure to higher doses of iron resulted in interference with testosterone production *in vitro* (Goyer, et al., 1995), stupor, shock, acidosis, hematemesis, bloody diarrhea, or coma (HSDB, 1999). Iron plays a critical role in generating oxidative radicals that can ultimately damage the liver (Goyer, et al., 1995). Mild to moderate toxicity has been observed at blood serum levels above 350 µg/dl, and greater than 500 µg/dl was associated with coma, intestinal radiopacities, leukocytosis, and a high risk of liver failure (Fuortes, 1999; Goyer, et al., 1995).

Lead

The primary effects of lead exposure are neurological, but also may include many hematological, renal, and cardiovascular effects and death. Lead exposure can decrease reaction time and affect memory. It can cause weakness in the fingers, wrists, and ankles. It also can cause increased blood pressure in men, angina, anemia, and cardiomyopathy. It has been linked with inhibiting enzymes associated with heme biosynthesis. At high levels of exposure, lead can seriously damage the brain and kidneys in adults and children. High levels of exposure to lead may cause miscarriage in pregnant women and damage organs responsible for sperm production in men. Lead has caused kidney tumors in rats and mice. Lead exposure is particularly dangerous in unborn and young children. Effects may include premature birth, low birth weight, decreased mental ability and Intelligence Quotient (IQ) scores, and reduced growth (ATSDR, 1999c).

Manganese

Manganese is an essential nutrient. Exposure to excess manganese may result in pulmonary inflammation following inhalation of particulates, Parkinson's-like symptoms, weakness, heaviness and stiffness of the limbs, muscle pain, nervousness, impotence, loss of libido, and headache. These studies are associated with high occupational exposures to manganese.

Studies indicate that manganese has low acute oral toxicity. High oral doses in laboratory rats resulted in an increase in death with the cause of death being nephropathy and renal failure. Animal studies have resulted in limited effects. Effects in animal studies were thyroid follicular hyperplasia, decreased weight gain, alterations in white blood cell counts, delayed reproductive function, and sperm morphological abnormalities. Carcinogenic potential in laboratory animals was equivocal. Human studies failed to show many effects after elevated exposures to manganese. The only significant effects reported after human exposures have been neurological. Effects include muscle rigidity, tremors, mental disturbance, weakness, abnormal gait, lack of muscle coordination, and Parkinson's-like symptoms. However, it is speculated that there may be other causative factors involved in addition to manganese. In general, other than acute neurological and immunological effects, most studies failed to show significant toxicity of manganese through oral and inhalation routes of exposure to human or animal organ systems (ATSDR, 1997c.

Mercury

The toxicity of mercury varies depending on the form of mercury. Mercury can be present as inorganic, organic or elemental mercury. Inhalation of organic and metallic mercury causes respiratory distress, chronic cough, dyspnea and edema of the lungs, increase in heart rate and blood pressure, inflammation of the oral cavity mucosa, thrombocytopenia, frequent nosebleeds, decreased hematocrit, muscular tremors, muscle pain, proteinuria, albuminuria, renal edema, proximal tubule damage, skin rashes, and reproductive impacts. Neurological impacts are significant and sensitive to mercury exposure. Dizziness, joint pain, weakness, insomnia, numbness and tingling of palms, irritability, outbursts, shyness, auditory hallucinations, photophobia, personality changes, headaches, nerve dysfunction, tremors, unsteady walking, and other neurological impact have been reported after intermediate and chronic exposure to mercury via inhalation. The primary target organs for oral exposure to mercury and mercury-containing compounds are the kidneys and the central nervous system. Effects associated with mercury are increased organ weight, increased body weight, abnormal gait, cardiovascular abnormalities, stomach ulcers, decreases in hemoglobin, hematocrit and red blood cell count, degeneration of renal tubules, glomerular changes, and many neurological effects as described for the inhalation exposure. (ATSDR, 1994a)

Naphthalene

High doses of naphthalene have been associated with mild to moderate irritation and inflammation of the olfactory epithelium, nausea, vomiting, abdominal pain, hemolytic anemia, pin-point lens opacities of the eye, headache, malaise, and confusion (ATSDR, 1995a).

Nickel

Inhalation exposure to nickel has been associated with pneumonia, atrophy of olfactory epithelium, labored breathing, lung inflammation, hyperplasia of lymph nodes, bronchiolar and alveolar adenoma and carcinoma, and benign and malignant pheochromocytoma. Oral exposure has been observed to cause allergic dermatitis, vomiting, cramps, diarrhea, muscular pain, increased white blood count, decreased heart, liver, and kidney weight, decreased body weight, cholesterol granulomas, emphysema, and bronchiolectasis (ATSDR, 1997d).

NO_x

NO_x is a precursor to other toxic compounds including nitric acid and ozone. When reacting with ammonia, moisture and other compounds, NO_x can form nitric acid that affects breathing and the respiratory system, cause emphysema, and aggravate heart disease. Information on ozone is listed under that compound (U.S. EPA, 1998).

Ozone

Ozone can cause respiratory irritation, reduce lung function, aggravate asthma, inflame and damage the lining of the lungs, and may aggravate chronic lung disease such as emphysema and bronchitis. Studies in animals suggest that it can reduce the immune response in the respiratory system. Many of these effects are short-term and reversible. However, repeated short-term damage may result in permanent injury to sensitive populations such as children and the elderly (U.S. EPA, 1999).

Polychlorinated Biphenyls

Inhalation of PCBs caused respiratory irritation, coughing, tightness of chest, changes in lung function, loss of appetite, weight loss, nausea, altered blood parameters, increases in liver enzymes, liver lesions in animals, slight degeneration of renal tubules, chloracne, skin rashes, eye irritation, tearing and burning, headache, dizziness, fatigue, nervousness, increased chromosomal aberrations, cancer of the liver, gall bladder and biliary tract, and kidney adenocarcinoma. Oral exposure to PCBs can cause high blood pressure, gastric changes, anemia, decreased hemoglobin, decreased hematocrit, increased liver enzymes, microsomal enzyme induction, fatty and necrotic liver changes, functional renal damage, changes to the thyroid, alteration of hormone production, skin lesions, reduced body weight, reduction in immune response, adverse reproductive effects, developmental effects (including reduced learning capability and IQ), liver neoplastic lesions, adenomas, and hepatocellular carcinomas (ATSDR, 1997e).

Selenium

Acute exposure to selenium via inhalation has been associated with pulmonary hemorrhage, pneumonitis, enlarged spleen, liver congestion, and increased liver weight in animals. Oral exposure resulted in decreased body weight, cirrhosis of the liver, abnormal sperm, decreased fertility and reproductive effects, brittle nails and bone, and amyloidosis of the heart, liver, kidney and adrenal gland (ATSDR 2001c).

Silver

Exposure to silver dust via inhalation resulted in respiratory irritation (sneezing, stuffiness, sore throat, and running nose), and abdominal pain. Most of the studies were done on silver smelting plants or exposure to silver compounds like silver nitrate. Oral exposure was associated with decreased weight gain, discoloration of the skin, and deposition in neurological tissue (ATSDR, 1990c).

Sulfur Dioxide

Inhalation of sulfur dioxide can cause significant respiratory effects, especially in sensitive subpopulations such as asthmatics, children, and the elderly. Effects that have been observed in humans are increase in specific airway resistance due to bronchoconstriction, decrease in Forced Expiratory Volume in 1 second (FEV1), decrease in Forced Vital Capacity (FVC), sloughing of the airway mucosa, edema of the alveoli, bronchial hypersensitivity, and bronchitis. These effects were increased when accompanied with exercise. There have been many studies on animals to investigate the cellular and physiological response to exposure to sulfur dioxide. Bronchitic lesions, decreased respiratory rate, rhinitis, tracheitis, bronchopneumonia, nasopharyngitis, lipid peroxidation of lung tissue, increased activities of acid phosphatase and alkaline phosphatase, decreased number of epithelial cells, increased number of leukocytes, damage to the epithelium accompanied with infiltration of leukocytes, destruction of cilia, and squamous cell metaplasia were observed in animal studies. Exposure to sulfur dioxide appears to affect immunological response with a higher prevalence of allergies, sensitization to allergens, and acute respiratory disease associated with exposure to sulfur dioxide (ATSDR, 1998b).

Toluene

Inhalation of toluene causes increased liver, lung, heart, kidney and body weight, irritation of lungs, nasal inflammation, neurological impacts (effects on gait, stride, and auditory response), renal impacts, headaches, and dizziness. Oral exposure was observed to cause increased liver weight, decreased body weight gain, diminished immune response, brain necrosis, and hypoactivity in animal studies (ATSDR, 1994b).

Zinc

Inhalation of zinc has been associated with decrease vital lung capacity, nausea, increased leukocytes, impaired lung function, increased lung weight, inflammation of lung tissue, and increased pulmonary resistance. Oral exposure can result in gastrointestinal distress, diarrhea, increased serum amylase and lipase, decreased hematocrit, intestinal hemorrhage, anemia, nephrosis, and reproductive effects (ATSDR, 1994c).

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Appendix I

Kentucky Fish Advisories

Kentucky Department for Environmental Protection

Division of Water

Kentucky Fish Advisories

FRANKFORT, KY (Oct. 10, 2000) - The Kentucky departments for Public Health, Environmental Protection, and Fish and Wildlife Resources today reissued fish consumption advisories for the Ohio River bordering Kentucky. These advisories continue, with minor changes, the ones issued in 1999 for some fish species caught in the Ohio River.

These advisories are based on the agencies' review of fish contamination information provided mainly by the Ohio River Valley Water Sanitation Commission (ORSANCO). The data used are from the years 1995-1999 for all listed species except paddlefish, which were sampled in 1991, 1998 and 1999. Fish were collected by various methods from diverse areas of the river, including lock chambers. Composites of fillets from each species were tested for organic chemical contaminants, such as PCBs, chlordane and, in limited areas, dioxin, and heavy metals (mercury, cadmium and lead).

"PCBs and mercury remain the main contaminants of concern from a public health perspective," said Rice Leach, M.D., Commissioner of the Department of Public Health. "The levels of contaminants have decreased to the point that many kinds of fish are now safe to eat at the advised frequency."

Following are consumption precautions for various tested species in three general areas of the Ohio River bordering Kentucky. If a species is not listed, no data is available. For some species, the advice is based on the size of the fish. The advice is based on a meal of ½ pound of fish (before cooking) eaten by a 150-pound individual. The special population includes pregnant women (and fetus), nursing mothers and their infants, and children. Women who may be or plan to become pregnant should also consider the special population advice.

UPPER REACH (Mouth of Big Sandy to Markland L & D)

Species	**General population**	**Special population**
Paddlefish (and eggs)	6 meals / year	No consumption
Carp	1 meal / month	6 meals / year
Channel catfish-Greater than (>) 21"	6 meals / year	No consumption
Channel catfish-Less than (<) 21"	1 meal / month	6 meals / year
Smallmouth buffalo	1 meal / month	6 meals / year
White bass	1 meal / week	1 meal / month
Drum	1 meal / month	6 meals / year
White crappie	Unlimited	1 meal / week
Hybrid striped bass	1 meal / month	6 meals / year
Sauger	1 meal / week	1 meal / month

MIDDLE REACH (Markland L & D to Cannelton L & D)

Species	**General Population**	**Special Population**
Paddlefish (and eggs)	6 meals / year	No consumption
Channel catfish >21"	6 meals / year	No consumption
Channel catfish <21"	1 meal / month	6 meals / year
Carp	1 meal / month	6 meals / year
Hybrid striped bass	1 meal / month	6 meals / year
White bass	1 meal / month	6 meals / year
Drum	1 meal / month	6 meals / year
Sauger	1 meal / week	1 meal / month

Black basses	1 meal / week	1 meal / month

LOWER REACH (Cannelton L & D to Mouth of Ohio River)

Species	**General Population**	**Special Population**
Paddlefish (and eggs)	6 meals / year	No consumption
Channel Catfish	1 meal / month	6 meals / year
Carp	1 meal / month	6 meals / year
Blue catfish >14"	1 meal / month	6 meals / year
Blue catfish <14"	1 meal / week	1 meal / month
Drum	1 meal / month	6 meals / year
Hybrid Striped bass	1 meal / month	6 meals / year
Sauger	1 meal / week	1 meal / month
White bass	1 meal / week	1 meal / month
Black basses	1 meal / week	1 meal / month
White crappie	unlimited	1 meal / week

Paddlefish were formerly listed as do not eat. However, paddlefish eggs and flesh had considerably lower levels of PCBs in the 1998 and 1999 samples than in 1991. Because of this, the advisory for paddlefish has been modified to allow limited consumption.

In April 2000, a statewide mercury advisory was issued for all freshwater fish from Kentucky waters, including the Ohio River. Women of childbearing age and children 6 years and younger should eat no more than one meal per week of any freshwater fish.

Chlordane has been removed as a contaminant of concern. Levels in the Kentucky portion of the river have decreased over the years since the advisory was first issued.

People who frequently eat fish, women of childbearing age and children are particularly susceptible to contaminants that build up in the body (such as PCBs and mercury). For this reason, childbearing-age women and children should follow the special population advisory. Women beyond their childbearing years and men face fewer health risks from contaminants. However, those persons should follow the general population advisory to reduce their total exposure and be especially careful to space out meals over time. Spacing out meals helps prevent contaminants from building up to harmful levels in the body.

If most of the meals you eat are from the "One Meal per Week" category, you should not exceed 52 meals per year. Likewise, if most of the fish you eat are from the "One meal per Month" category, you should not exceed 12 meals per year. Eating one meal of fish from the "One Meal per Month" category is equivalent to eating four fish meals from the "One Meal per Week" group.

Proper cleaning, skinning, trimming and cooking can reduce contaminant levels in the fish. Eat only skinless, boneless fillets with as much fat as possible removed. Do not eat the skin, which can contain higher levels of fat. Eggs should be discarded. Roasting, baking or broiling have been found to reduce levels of PCBs and chlordane more than other cooking methods. Cooking does not destroy contaminants nor does it lower their toxicity. The heat melts some of the fat in the fish, removing some of the contaminants at the same time. Do not eat or reuse the fat and juices that cook out of the fish. **Cooking will not reduce mercury levels possibly found in fish.**

Advisories before 1998 were based on contaminant levels, particularly PCBs, mercury and chlordane, exceeding U.S. Food and Drug Administration (FDA) "action level" guidelines. Those guidelines were originally developed for seafood in the market. They were then adapted for sport fish advisories by many states.

Over the past few years, most states have moved away from using FDA action levels for their sport fish consumption advisories. The USEPA has developed risk-based guidelines for many contaminants, including mercury. The Great Lakes Sport Fish Advisory Task Force has developed an advisory protocol for PCBs that, among other things, better protects unborn and infant children. The protocol also gives better information on amounts of fish that can be safely consumed. This advisory protocol has been adopted by all the Great Lakes states.

Those Great Lakes states bordering on the Ohio River have been using the Great Lakes Protocol (GLP) to issue advisories on the river. West Virginia, which is not a Great Lakes state, is also using the GLP on the Ohio River. Kentucky began using the risk-based Great Lakes Protocols for PCBs on the Ohio River in 1998 and on in-state streams and lakes in 1999.

This action is being taken to inform the public about the possible risks of eating unrestricted amounts of some fish from the Ohio River. The monitoring of tissue residue levels in fish from the Ohio River is an ongoing program of the state agencies in cooperation with ORSANCO.

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